KERALA AGRICULTURAL UNIVERSITY

ORGANIZATION OF COURSE CONTENTS & CREDIT REQUIREMENTS

Code Numbers

- **All courses are divided into two series: 500-series courses pertain to Master's level,and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme**.
- **Credit seminar for Master's level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively**.
- **Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively**.

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if already studied during Master's degree**.**

Subject	Master's programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	**55**	**75**
Compulsory Non Credit Courses	**6**	

Inter-institutional Transfer of Credits

Once the unified national PG curriculum and common academic regulations get implemented, the students may be permitted to transfer credits from one institution to another in case of unavoidable migration. Migration of students admitted through ICAR quota should not be allowed. The migration rules may be framed by the individual SAUs, and due care need be exercised to avoid inbreeding in students.

SYLLABUS

I AGRONOMY

COURSE STRUCTURE – AT A GLANCE

CODE COURSE	COURSE TITLE	CREDITS
AGRON 501*	MODERN CONCEPTS IN CROP PRODUCTION	3+0
AGRON 502*	PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT	2+1
AGRON 503*	PRINCIPLES AND PRACTICES OF WEED MANAGEMENT	2+1
AGRON 504*	PRINCIPALES AND PRACTICES OF WATER MANAGEMENT	2+1
AGRON 505	AGROMETEROLOGY AND CROP WEATHER FORECASTING	2+1
AGRON 506	AGRONOMY OF MAJOR CEREALS AND PULES	2+1
AGRON 507	AGRONOMY OF OILSEED,FIBRE AND SUGAR CROPS	2+1
AGRON 508	AGRONOMY OF MEDICINAL ,AROMATIC AND UNDER UTILIZED CROPS	2+1
AGRON 509	AGRONOMY OF FODDER AND FORAGE CROPS	2+1
AGRON 510	AGROSTOLOGY AND AGROFORESTRY	2+1
AGRON 511	CROPPING SYSTEMS	2+0
AGRON 512	DRYLAND FARMING	2+1
AGRON 513	PRINCIPLES AND PRACTICES OF ORGANIC FARMING	2+1
AGRON 514	**A**GRONOMY OF TUBERCROPS	2+ 1
AGRON 591	MASTERS SEMINAR	0+1
AGRON 599	MASTER'S RESEARCH	20
AGRON 601**	CURRENT TRENDS IN AGRONOMY	3+0
AGRON 602	CROP ECOLOGY	2+0
AGRON 603	CROP PRODUCTION AND SYSTEM MODELING	2+1
AGRON 604**	ADVANCES IN CROP GROWTH AND PRODUCTIVITY	2+1
AGRON 605**	IRRIGATION MANAGEMENT	2+1
AGRON 606**	ADVANCES IN WEED MANAGEMENT	2+0
AGRON 607	INTEGRATED FARMING SYSTEM	2+0
AGRON 608	SOIL CONSERVATION AND WATERSHED MANAGEMENT	2+1
AGRON 609	STRESS CROP PRODUCTION	2+1
AGRON 610	ENVIRONMENTAL PROTECTION AND POLLUTION CONTROL	2+1
AGRON 691	DOCTORAL SEMINAR 1	0+1
AGRON 692	DOCTORAL SEMINAR 11	0+1
AGRON 699	DOCTORAL RESERCH	45
	REMEDIAL COURSES	
AGRON 01***	PRINCIPLES OF AGRONOMY	2+1
AGRON 02***	CROP PRODUCTION	2+1

*** Compulsory for Master's Programme**
**** Compulsory for Ph.D Programme**
***** Remedial Courses for Non- Agricultural PG students**

1. AGRON 501 MODERN CONCEPTS IN CROP PRODUCTION 3+0

Objective

To teach the basic concepts of soil management and crop production.

Theory

UNIT I

Crop growth analysis in relation to environment; agro-ecological zones of India.

UNIT II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

UNIT III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

UNIT IV

Scientific principles of crop production; crop response production functions; concept of soil- plant relations; yield and environmental stress.

UNIT V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture, crop residue recycling and management, sustainable agriculture and good agriculture practices.

Suggested Readings

Alvin, P.T. and Kozlowski, T.T. (ed.). 1976. *Ecophysiology of Tropical Crops.* Academic Publications, New York

Balasubramaniyan, P. and Palaniappan, S.P. 2001. *Principles and Practices of Agronomy*. Agrobios, Jodhpur.

Fageria, N.K. 1992. *Maximizing Crop Yields*. Marcel Dekker, New York.

Gardner, P.P., Pearce, G.R. and Mitchell, R.L.1985. *Physiology of Crop Plants.* Scientific Pub., Jodhpur.

Havlin, J.L, Beaton, J.D., Tisdale, S.L. and Nelson, W.L. 2006. *Soil Fertility and Fertilizers* (7th Ed). Prentice Hall of India, New Delhi.

Lal, R. 1989. Conservation tillage for sustainable agriculture: Tropics versus temperate environments. *Advances in Agronomy* 42: .85-197

Paroda, R.S. 2003. *Sustaining our Food Security*. Konark Publishers, Ludhiana.

Reddy, S.R. 2000. *Principles of Crop Production*. Kalyani Publishers, Ludhiana.

Sankaran S & Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publishers, Bangalore.

Wilsie, C. P. 1961. *Crop Adaptation and Distribution*, Eurasia Pub., New Delhi.

2. AGRON 502 PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT 2+1

Objective

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

UNIT I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

UNIT II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

UNIT III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

UNIT IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions.

UNIT V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; Soil amendments in relation to nutrient management -Nutrient management in cropping systems; nutrient management in problem soils , fertilizer use & environmental quality

UNIT VI

Importance of soil micro-organisms in nutrient management; Bio-fertilizers-increasing efficiency - limitations; quality control of fertilizers, organic manures & biofertilisers-legislation

Practical

- Determination of soil pH, EC, organic C, total N, available N, P, K and S in soils
- Determination of total N, P, K and S in plants
- Interpretation of interaction effects and computation of economic and yield optima

Suggested Readings

Brady, N. C and Weil, R.R 2002. *The Nature and Properties of Soils (* 13th Ed.). Pearson Education.

Fageria, N.K., Baligar, V.C. and Jones, C.A. 1991. *Growth and Mineral Nutrition of Field Crops*, Marcel Dekker, New York.

Havlin, J.L, Beaton, J.D., Tisdale, S.L. and Nelson, W.L. 2006. *Soil Fertility and Fertilizers* (7^{th} Ed.) Prentice Hall of India, New Delhi.

Prasad, R. and Power, J. F. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC-Lewis, Boca Raton, Florida.

Yawalkar, K.S., Agrawal, J.P. and Bokde, S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.

3. AGRON 503 PRINCIPLES AND PRACTICES OF WEED MANAGEMENT 2+1

Objective

To familiarize the students about the weeds, herbicides and methods of weed control

Theory

UNIT I.

Weed biology and ecology - crop – weed interference – principles of weed management – classification of weed management techniques – weed indices

UNIT II.

Herbicides – introduction – history – classification based on chemical, physiological, methods of application and selectivity– mode and mechanism of action – herbicide selectivity – herbicide antidotes/safeners

UNIT III

Herbicide structure and properties – factors affecting the efficiency of herbicides – herbicide formulations – herbicide mixtures -Degradation of herbicides in soil and plants -Herbicide resistance in weeds and management – weed shift in cropping systems- weed control through bioherbicides and allelochemicals—herbicide resistant crops - herbicide rotation

UNIT IV

Weed management in major crops, cropping systems and non – cropped situations — control of parasitic weeds – control of aquatic and perennial weeds

UNIT – V

Integrated weed management - economics of weed management – new trends in weed management

Practical

- Identification of important weeds and preparation of herbarium
- Weed survey in crops and cropping systems
- Crop - weed competition studies
- Calibration of sprayers
- Calculation of herbicide requirements
- Use of various types of spray pumps and nozzles
- Preparation of spray solutions and application of herbicides
- Herbicide residue bioassay
- Studies on allelopathic influence of various crops and weeds
- Planning and execution of weed control experiments

Suggested Readings

Aldrich, R.J., Kramer, R.J. 1997. *Principles in Weed Management*. Panima publ.

Ashton, F.M and Crafts, A.S. 1981. *Mode of Action of Herbicides* (2nd Ed). Wiley inter Science.

Gupta,O.P. 2007. *Weed management – Principles and Practices*. Agrobios

Mandal, R. C, 1990. *Weed, weedicides and weed control – Principles and Practices*. Agro – Botanical Publ.

Rao, V.S. 2000. *Principles of Weed Science.* Oxford & IBH

Subramanian, S. Ali, A.M and Kumar, RJ. 1997. *All About Weed Control*. Kalyani

Thomas, C.G. and Abraham, C.T. 2007. *Methods in Weed Science.* Kerala Agricultural University, Vellanikkara

Zimdahl RL. 1999. *Fundamentals of Weed Science* (2nd Ed). Academic Press

4. AGRON 504 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT 2+1

Objective

To teach the principles of water management and practices to enhance the water productivity.

Theory

UNIT I

Water and its role in plants; Irrigation and irrigation management –definition objectives-limitations-water resources of India and Kerala- Irrigation statistics – present and future expansion or gaps in India and Kerala-major irrigation projects of India and Kerala, extent of area and crops irrigated in India and different states.

UNIT II

Soil water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant /crop response to water stress, crop plant adaptation to moisture stress condition.

UNIT III

Water requirement of crops-Soil, plant and meteorological factors and methods of determining water needs of crops; Irrigation scheduling, depth and methods of irrigation; micro irrigation system;fertigation; management of water in controlled environments and polyhouses. Concepts of – ET, CU, PET, ETc, Epan and their importance in assessing WR. IW/CPE ratio and its importance

UNIT IV

Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; Leaching requirement, irrigation efficiencies and methods of increasing field water use efficiency.

UNIT V

Excess water and plant growth; water management in problem soils; drainage requirement of crops, drainage coefficient and methods of field drainage, their layout and spacing.

Practical

- Direct and indirect methods of soil moisture determination using tensiometer, and pressure plate and membrane apparatus and resistance blocks
- Soil-moisture characteristics curves and its importance
- Water flow measurements using different devices
- Determination of irrigation requirements of crops
- Calculation of irrigation efficiency
- Determination of infiltration rate of soils and hydraulic conductivity
- Study of micro irrigation systems and their layout in field crops

Suggested Readings

Hansen, V.E., Israelsen, O.W., and Stringham, G.E. 1979. *Irrigation Principles and Practices* (4th Ed.). John Wiley and Sons, New York

Lenka D.1999. *Irrigation and Drainage.* Kalyani publishing House, Ludhiana.

Michael, A.M. 1978. *Irrigation: Theory and Practice*. Vikas Publishing House, New Delhi.

Mishra.R.D. and Ahamed, M.1993. *Manual of Irrigation Agronomy*. Oxford and IBH Publishing Co., New Delhi

Paliwal, K.V. 1972. *Irrigation with Saline Water*. WTC, IARI, New Delhi.

Panda, S. C. 2003. *Principles and Practices of Water Management*. Agrobios.

Prihar, S. S. and Sandhu.B.S.1987. *Irrigation of Field Crop*s - Principles and practices, ICAR, New Delhi.
Sankara Reddi, G.H. and Yellamanda Reddy, T. 2003 *Efficient Use of Irrigation Water*. Kalyani , Ludhiana.
Singh, P. and Maliwal, P. L. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

5. AGRON 505 AGROMETEOROLOGY AND CROP WEATHER FORECASTING 2+1

Objective

To impart knowledge about agro-meteorology and crop weather forecasting to meet the challenges of aberrant weather conditions.

Theory

UNIT I

Agro meteorology - aim, scope and development in relation to crop environment; composition of atmosphere, distribution of atmospheric pressure and wind.

UNIT II

Characteristics of solar radiation; energy balance of atmosphere system; radiation distribution in plant canopies, radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops; energy budget of plant canopies; environmental temperature: soil, air and canopy temperature.

UNIT III

Temperature profile in air, soil, crop canopies; soil and air temperature effects on plant processes; environmental moisture and evaporation: measures of atmospheric temperature and relative humidity vapor pressure and their relationships; evapo-transpiration and meteorological factors determining evapotranspiration.

UNIT IV

Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation.

UNIT V

Weather forecasting in India – short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture.

Practical

- Visit to agro-meteorological observatory and to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure
- Measurement of solar radiation outside and within plant canopy
- Measurement/estimation of evapo-transpiration by various methods
- Measurement/estimation of soil water balance
- Rainfall variability analysis
- Determination of heat-unit requirement for different crops
- Measurement of crop canopy temperature
- Measurement of soil temperatures at different depths
- Remote sensing and familiarization with agro-advisory service bulletins

- Study of synoptic charts and weather reports, working principle of automatic weather station
- Visit to solar observatory

Suggested Readings

Chang Jan Hu ,1968. *Climate and Agriculture on Ecological Survey*. Aldine Publ.
Critchfield, H. J.1995. *General Climatology.* Prentice Hall of India.
Das, P. K.1968. *The Monsoons*. National Book Trust Publ.
Lal, D. S.1998. *Climatology*. Sharda Pustak Bhawan.
Lenka, D.1998. *Climate, Weather and Crops in India*. Kalyani.
Mavi, H.S.1994. *Introduction to Agro-meteorology*. Oxford & IBH.
Mavi, H. S and Tupper, G. J. 2004. *Agrometeorology: Principles and Application of Climate Studies in Agriculture.* Haworth Press.
Menon PA.1991. *Our Weather.* National Book Trust Publ.
Sahu, D. D. *Agrometeorology and Remote Sensing: Principles and Practices*. Agrobios.
Variraju R and Krishnamurty 1995. *Practical Manual on Agricultural Meteorology*. Kalyani.
Varshneya, M.C. and Balakrishana Pillai, P. 2003. *Textbook of Agricultural Meteorology*. ICAR.

6. AGRON 506 AGRONOMY OF MAJOR CEREALS AND PULSES 2+1

Objective

To teach the crop husbandry of cereals and pulse crops.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production**,** value addition and agro-based industries of:

UNIT I
Rabi cereals.
UNIT II
Kharif cereals.
UNIT III
Rabi pulses.
UNIT IV
Kharif pulses.

Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (CGR, RGR, NAR, LAD), LER, aggressiveness, relative crowding coefficient, monetary yield advantage and ATER (Area Time Equivalent Ratio) of prominent intercropping systems of different crops
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops

- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

Das, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.
Hunsigi, G. and Krishna, K. R. 1998. *Science of Field Crop Production*. Oxford & IBH.
Jeswani, L.M. and Baldev, B. 1997. *Advances in Pulse Production Technology*. ICAR.
Khare, D. and Bhale, M. S. 2000. *Seed Technology*. Scientific Publ.
Kumar Ranjeet and Singh, N. P. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.
Pal, M. , Deka, J. and Rai RK. 1996. *Fundamentals of Cereal Crop Production*. Tata McGraw Hill.
Prasad, R. 2002(ed.). *Text Book of Field Crop Production*. ICAR.
Singh, C., Singh, P. and Singh, R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
Singh, S.S. 1998. *Crop Management*. Kalyani.
Yadav, D. S. 1992. *Pulse Crops*. Kalyani.

7. AGRON 507 AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS 2+1

Objective

To teach the crop husbandry of oilseed, fiber and sugar crops.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition quality component, handling and processing of the produce for maximum production of :

UNIT I

Rabi oilseeds – Rapeseed and mustard, linseed, etc.

UNIT II

Kharif oilseeds - Groundnut, sesame, castor, sunflower, soybean etc.

UNIT III

Fiber crops - Cotton, jute, sunhemp etc.UNIT IV

Sugar crops – Sugar-beet and sugarcane.

Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice
- Phenological studies at different growth stages of crop, visit to a sugarcane research station
- Intercultural operations in different crops
- Cotton seed treatment

- Working out growth indices (CGR, RGR, NAR, LAD), LER, aggressiveness, relative crowding coefficient, monetary yield advantage and ATER (Area Time Equivalent Ratio) of prominent intercropping systems of different crops
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

Das, N.R. 2007. *Introduction to Crops of India*. Scientific Publ.
Das, P.C. 1997. *Oilseed Crops of India*. Kalyani.
Lakshmikantam, N. 1983. *Technology in Sugarcane Growing* (2nd Ed.) Oxford & IBH.
Prasad, R. 2002 (ed.). *Text Book of Field Crop Production*. ICAR.
Singh ,C, Singh, P. and Singh R. 2003. *Modern Techniques of Raising Field Crops.* Oxford & IBH.
Singh, S. S. 1998. *Crop Management*. Kalyani.

8. AGRON 508 AGRONOMY OF MEDICINAL, AROMATIC AND UNDER-UTILIZED CROPS 2+1

Objective

To acquaint students about different medicinal, aromatic and underutilized field crops, their package of practices and processing.

Theory

UNIT I

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and uses, conservation of medicinal plants

UNIT II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (*Rauwolfia, Aloe vera*, Kacholam, Stevia, Chethikoduveli**,** Black Musali**,** Thippali**,** *Nux vomica*, etc). and value addition

UNIT III

Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium, etc.).

UNIT IV

Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Cluster beans, French bean, Mucuna, Fenugreek, Grain Amaranth)

Practical

- Identification of crops based on morphological and seed characteristics
- Cultivation techniques of medicinal and aromatic plants
- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants and value addition.
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants

Suggested Readings

Chadha, K. L. and Gupta, R. 1995. *Advances in Horticulture*. Vol. II. *Medicinal and Aromatic Plants*. Malhotra Publ.

Das, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.

Handa, S. S. 1984. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Hussain, A. 1984. *Essential Oil Plants and their Cultivation*. CIMAP, Lucknow.

Hussain A. 1993. *Medicinal Plants and their Cultivation.* CIMAP, Lucknow.

ICAR 2006. *Hand Book of Agriculture.* ICAR, New Delhi.

Kumar, N., Khader, Md. A., Rangaswami, J.B.M. Irulappan 1997. I*ntroduction to Spices, Plantation Crops, Medicinal and Aromatic Plants.* Oxford & IBH.

Prajapati, N.D., Purohit, S.S., Sharma, A.K. and Kumar, T. 2003. *A Hand Book of Medicinal Plants: A Complete Source Book.* Agrobios.

Sharma, R. 2004. *Agro-Techniques of Medicinal Plants*. Daya Publ. House.

9. AGRON 509 AGRONOMY OF FODDER AND FORAGE CROPS 2+1

Objective

To teach the crop husbandry of different forage and fodder crops along with their processing.

Theory

UNIT I

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like maize, sorghum, *bajra*, oats, barley, *guar*, cowpea, berseem, lucerne, etc.

UNIT II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses like napier, hybrid napier, Panicum, Cenchrus, congo signal, signal**,** gamba, setaria**,** para, dheenanath, etc.

UNIT III

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important perennial legumes forage crops like stylo, subabul, calliandra, desmanthes, *etc.* - Production and utilization of azolla**.**

UNIT IV

Year-round fodder production and management- *Fodder crops under coconut,* Preservation and utilization of forage and pasture crops.

UNIT V

Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder.

UNIT VI

Economics of forage cultivation uses and seed production techniques.

Practical

- Practical raining of farm operations in raising fodder crops;
- Canopy measurement, yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose etc. of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation

Suggested Readings

Chatterjee, B.N. and Das, P.K. 1989. *Forage Crop Production - Principles and Practices*. Oxford & IBH, New Delhi.

Gohl, B. 1981. *Tropical Feeds: Feed Information Summaries and Nutritive Values.* FAO Animal Production and Health Series, No. 12. FAO, Rome.

Narayanan, T.R. and Dabadghao, P.M. 1972. *Forage Crops of India*, ICAR, New Delhi.

NAS [National Academy of Sciences]. 1979. *Tropical Legumes- Resources for the Future.* National Academy of sciences, Washington DC.

Plucknett, D. L.1979. *Managing Pastures and Cattle Under Coconuts*. Westview Tropical Agriculture Series, No.2, Westview press/Boulder, Colorado.

Reynolds, S.G. 1995 *Pasture-Cattle-Coconut Systems*. FAO-RAPA Publication: 1995/7, FAO-RAPA, Bangkok, Thailand..

Singh, R.P. (ed.).1995. *Forage Production and Utilization*. Indian Grassland and Fodder Research Institute, Jhansi.

Skerman P.J. and Riveros F. 1990. *Tropical Grasses*. FAO Plant Production and Protection Series Food and Agriculture Organization of the United Nations, Rome.

Skerman P.J., Cameron, D.G., and Riveros, F.1988. *Tropical Forage Legumes* (2nd ed.) Food and Agriculture Organization of the United Nations, Rome.

Tejwani KG. 1994. *Agroforestry in India*. Oxford & IBH.

Thomas, C.G. 2008. *Forage Crop Production in the Tropics* (2nd Ed.) Kalyani Publishers, Ludhiana.

Whiteman, P.C. 1980. *Tropical Pasture Science*. Oxford University Press, New York.

10. AGRON 510 AGROSTOLOGY AND AGRO-FORESTRY 2+1

Objective

To teach crop husbandry of different forage, fodder and agroforestry crops/trees along with their processing.

Theory

UNIT I

Agrostology: definition and importance; principles of grassland ecology: grassland ecology – community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

UNIT II

Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

UNIT III

Agroforestry: definition and importance; agroforestory systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.

UNIT IV

Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation

and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical

- Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination of farm vegetation
- Methods of propagation/planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvipastroal systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry research stations

Suggested Readings

Chatterjee, B.N. and Das, P.K. 1989. *Forage Crop Production. Principles and Practices.* Oxford & IBH.

Dabadghao, P.M. and Shankaranarayan, K.A. 1973. *The Grass Cover in India*. ICAR.

Dwivedi, A.P. 1992. *Agroforestry- Principles and Practices.* Oxford & IBH.

ISA[Indian Society of Agronomy]. 1989. *Agroforestry System in India. Research and Development,* New Delhi.

Narayan, T.R. and Dabadghao, P.M. 1972. *Forage Crop of India*. ICAR, New Delhi.

Pathak, P.S. and Roy, M.M. 1994. *Agroforestry System for Degraded Lands*. Oxford & IBH.

Sen, N, L, Dadheech, R.C, Dashora, L.K and Rawat, T. S. 2004. *Manual of Agroforestry and Social Forestry.* Agrotech Publ.

Shah, S.A.1988. *Forestry for People*. ICAR.

Singh P., Pathak, P.S., and Roy, M.M.1994. *Agroforestry System for Sustainable Use*. Oxford & IBH.

Singh, S.P. 1994. *Handbook of Agroforestry.* Agrotech Publ.

Solanki, K.R. 2000. *Multipurpose Tree Species: Research, Retrospect and Prospects*. Agrobios.

Tejwani, K.G.1994. *Agroforestry in India.* Oxford & IBH.

11. AGRON 511 CROPPING SYSTEMS 2+0

Objective

To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity

Theory

UNIT I

System approach- cropping system, definition and importance-physical resources and its management in cropping systems- Multiple cropping-intercropping, sequential cropping, alley cropping-advantages- interactions in cropping systems- complimentary

interactions- competitions- allelopathic effect-role of non monetary inputs and low cost technologies-input use efficiency in cropping systems

UNIT II

Assessment of yield advantage in intercropping system-assessment of land use- indices-economic evaluation of cropping systems- Important cropping systems of India and Kerala-multi storied cropping

UNIT III

Mixed farming-IFS- choice of enterprises- interaction among enterprises-advantages-IFS models for different situations

UNIT IV

Sustainability- concept, scope and objectives- LEIA, LEISA, HEIA -organic farming-crop diversification for sustainability-role of organic matter in sustainability-crop residue management-sustainable technologies in crop production and management

UNIT V

Plant ideotype for dry lands- plant growth regulators and their role in sustainability

Suggested Readings

Gangopadhyay, A. 2007. *Crop Production Systems and Management*. Gene Tech Books

Bandopadhyay, A., Sundaram, K. V., Moni, M., Kundu, P.S., Mrityunjay and Jha, M..(eds). 2005. *Sustainable Agriculture-Issues in production, Management , Agronomy and ICT Application*

Palaniappan, S.P. and Sivaraman, K. 1996. *Cropping Systems in the Tropics: Principles and Management.* New Age Publishers

Panda, S. C. 2003. *Cropping and Farming Systems*. Agrobios

Reddy, S. R. 2000. *Principles of Crop Production*. Kalyani

Sankaran, S. and Mudaliyar, T.V.S.1997. *Principles of Agronomy*. The Bangalore Printing &Publishing Co.

Singh, S. S. 2006. *Principles and Practices of Agronomy*, Kalyani

12. AGRON 512 DRYLAND FARMING 2+1

Objective

To teach the basic concepts and practices of dry land farming and soil moisture conservation.

Theory

UNIT I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture. Extent of dryland area in India, agencies and programmes of dryland agriculture in India

UNIT II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

UNIT III

Stress physiology and crop resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

UNIT IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; types and their mode of action; soil and crop management techniques, seeding and efficient fertilizer use, steps to enhance water use efficiency of dry land crops.

UNIT V

Concept of watershed resource management, problems, approach and components, classification, codification, objectives, strategies, case studies in dry farming situation.

Practical

- Seed treatment, seed germination and crop establishment in relation to soil moisture contents
- Moisture stress effects and recovery behaviour of important crops
- Estimation of moisture index and aridity index
- Spray of anti-transpirants and their effect on crops
- Collection and interpretation of data for water balance equations
- Water use efficiency
- Preparation of crop plans for different drought conditions
- Study of field experiments relevant to dryland farming
- Visit to dryland research stations and watershed projects

Suggested Readings

Das, N.R. 2007. *Tillage and Crop Production*. Scientific Publishers.

Dhopte. A.M. 2002. *Agro technology for Dry land Farming*. Scientific Publ.

Dhruv Narayana, V.V. 2002. *Soil and Water Conservation Research in India*. ICAR.

Gupta, U.S. (Ed.). 1995. *Production and Improvements of Crops for Drylands*. Oxford & IBH.

Katyal, J.C. and Farrington, J. 1995. *Research for Rainfed Farming*. CRIDA.

Rao, S.C. and Ryan, J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publishers.

Singh, P. and Maliwal, P.L. 2005. *Technologies for Food Security and Sustainable Agriculture.* Agrotech Publishing Company.

Singh, R.P. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.

Singh, R.P. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.

Singh, S.D. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publishers.

Venkateshwarlu, J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

13. AGRON 513 PRINCIPLES AND PRACTICES OF ORGANIC FARMING 2+1

Objective

To study the principles and practices of organic farming for sustainable crop production.

Theory

UNIT I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; land and water management - land use, minimum tillage; shelter zones, hedges, pasture management, agro-forestry.

UNIT II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures and biofertilizers.

UNIT III

Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

UNIT IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, biopesticides.

UNIT V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Aerobic and anaerobic methods of making compost
- Making of vermicompost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium cultures, use of Azotobacter, Azospirillum, and PSB cultures in field
- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Suggested Readings

Ananthakrishnan, T. N. (ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

Gaur, A.C. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document, FAO.

Lampkin, N. 1990. *Organic Farming*. Press Books, lpswitch, UK.

Palaniappan, S.P and Anandurai, K. 1999. *Organic Farming – Theory and Practice*. Scientific Publ.

Rao, B.V.V. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, Parisaraprajna Parishtana, Bangalore.

Reddy M.V. (ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.

Sharma, A. 2002. *Hand Book of Organic Farming*. Agrobios.

Singh, S. P. (ed.) 1994. *Technology for Production of Natural Enemies.* PDBC, Bangalore.

Subba Rao, N.S. 2002. *Soil Microbiology*. Oxford & IBH.

Trivedi, R. N.1993. *A Text Book of Environmental Sciences*, Anmol Publ.

Veeresh, G. K, Shivashankar, K. and Singlachar, M. A. 1997. *Organic Farming and Sustainable Agriculture.* Association for Promotion of Organic Farming, Bangalore.

WHO. 1990. *Public Health Impact of Pesticides Used in Agriculture*.WHO.

Woolmer PL & Swift MJ. 1994. *The Biological Management of Tropical Soil Fertility*. TSBF & Wiley.

14. AGRON 514 AGRONOMY OF TUBERCROPS 2+ 1

Objective

To teach the crop husbandry of tuber crops.

Theory

Origin, history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production, value addition and agro-based industries of:

UNIT I

Potato

UNIT II

Cassava

UNIT III

Sweet potato

UNIT IV

Yams, aroids, arrow roots and minor tuber crops

UNIT V

Tuber crop based cropping systems

UNIT VI

Review of research on agronomy of tuber crops and research needs

Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (CGR, RGR, NAR, LAD), LER, aggressiveness, relative crowding coefficient, monetary yield advantage and ATER (Area Time Equivalent Ratio) of prominent intercropping systems of different crops
- Estimation of starch and protein content in various tuber crops
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of propagation techniques in various tuber crops
- Visit to experimental fields on cultural, fertilizer, weed control and water anagement aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

Baekema, H.P. and Zaag, D.E.V.D. 1990. *Introduction to Potato Production*. Pudoc, Wageningen.

Coursey, D.G .1967. *Yams.*Longman, London.

Grace, M.R.1977.*Cassava processing*. FAO plant production and protection series No.3.Food and Agriculture Organization of United Nations ,Rome.

Hillocks, R. J.,Tresh ,J.M., and Bellotti ,A.C .2002.*Cassava: Biology, Production and Utilization.* New York:CABI publishing.

Lebot, L. 2009. *Tropical Root and Tuber Crops – Cassava, Sweet potato, Yams, and Aroids.* CABI publishing.

Norman, M. J. T., Pearson, C.J. and Searle, P.G.E.1995.*Tropical Food Crops in Their Environment* (2nd ed.). Cambridge University Press.
Onwueme, IC.and Charles.W.D.1994. Tropical Root and Tuber Crops-production,prespective and future prospects.F.A.O.production and protection paper - 126,Rome.
Oke,O.L.1990.Roots,Tubers,Plantains and Bananas in Human Nutrition.Food and Agriculture Organization of the United Nations ,Rome.
Purseglove, J.W.1972.*Tropical Crops:Monocotyledons*.Longman,London.purseglove,
Purseglove, J.W.1974.*Tropical Crops:Dicotyledons*.Longman,London.
Woolfe, J.A.1987.*The pototo in the Human Diet.* Cambridge University press, Cambridge.
Woolfe,J.A. 1992.*Sweet potato: An Untapped food Resource*. Cambridge University presss, Cambridge.

PH.D COURSES

1. AGRON 601 CURRENT TRENDS IN AGRONOMY 3+0

Objective

To acquaint the students about recent advances in agricultural production.

Theory

UNIT I

Agro-physiological basis of variation in yield, recent advances in soil-plant- water relationship.

UNIT II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures.

UNIT III

Crop residue management in multiple cropping systems; latest developments in plant management, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

UNIT IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

UNIT V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

Suggested Readings

Agarwal RL. 1995. *Seed Technology*. Oxford & IBH.

Dahiya BS & Rai KN. 1997. *Seed Technology*. Kalyani.

Govardhan V. 2000. *Remote Sensing and Water Management in Command Areas: Agroecological Prospectives*. IBDC.

ICAR. 2006. *Hand Book of Agriculture*. ICAR.

Narasaiah ML. 2004. *World Trade Organization and Agriculture*. Sonali Publ.

Palaniappan SP & Annadurai K. 2006. *Organic Farming - Theory and Practice*. Scientific Publ.

Sen S & Ghosh N. 1999. *Seed Science and Technology*. Kalyani.

Tarafdar JC, Tripathi KP & Mahesh Kumar 2007. *Organic Agriculture*. Scientific Publ.

2. AGRON 602 CROP ECOLOGY 2+0

Objective

To acquaint the students about the agricultural systems, agro-ecological regions, and adaptation of crops to different agro-climatic conditions.

Theory

UNIT I

Concept of crop ecology, agricultural systems, ecology of cropping systems, Competition in crop plants ,principles of plant distribution and adaptation- world food supply.

UNIT II

Concept and dynamics of ecosystems- Ecosystem characteristics, types and functions of ecosystem, Aquatic and terrestrial ecology, Ecological processes, flow of energy in

ecosystem, ecological pyramids,Trophic levels, and food chain ecosystem productivity, biomass, succession and climax concept. Biogeochemical cycles, Ecology of nutrient cycling

UNIT III

Physiological response of crop plants to light, temperature, CO2, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops; effect of global climate change on crop production.

UNIT IV

Exploitation of resources in crops; vertical distribution of temperature; Efficiency in crop production. Resource Use Efficiency

UNIT V

Environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices; improvement of unproductive lands through crop selection and management.

Suggested Readings

Alteri, M. A.1995. *Agroecology; the science of sustainable agriculture*(2nd ed.) Westview Press, Boulder, Colorado, USA

Ambasht RS. 1986. *A Text Book of Plant Ecology* (9th Ed). Students' Friends

Chadha KL & Swaminathan MS. 2006. *Environment and Agriculture*. Malhotra Publ. House.

Dwivedi P, Dwivedi SK & Kalita MC. 2007. *Biodiversity and Environmental Biotechnology.* Scientific Publ.

Gliessman,S.R. Agroecology; researching the ecological basis in sustainable agriculture. Ann. Arbour Press, Michigan

Hemantarajan A. 2007. *Environmental Physiology*. Scientific Publ.

Kumar HD. 1992. *Modern Concepts of Ecology* (7th Ed). Vikas.Publ.

Lenka D. 1998. *Climate, Weather and Crops in India*. Kalyani.

Misra KC. 1989. *Manual of Plant Ecology* (3rd Ed). Oxford & IBH.

Pandey SN & Sinha BK. 1995. *Plant Physiology*. Vikas Publ.

Sharma PD. 1998. *Ecology and Environment*. Rastogi Publ.

Singh J & Dhillon SS. 1984. *Agricultural Geography.* Tata McGraw Hill.

Taiz L & Zeiger E. 1992. *Plant Physiology*. Benjamin/Cummings Publ.

3. AGRON 603 CROP PRODUCTION AND SYSTEM MODELLING 2+1

Objective

To familiarize the students about systems approach and to simulate yields and growth of several crops under varied soil and weather conditions with different management practices and their optimization.

Theory

UNIT I

Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams.

UNIT II

Elementary models for crop growth based on basic methods of classical growth analysis.

UNIT III

Crop modeling methods for crop-weather interaction, climate change and variability components.

UNIT IV

Potential production: leaf and canopy CO2 assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.

UNIT V

Production by moisture availability, potential evapotranspiration, water balance of the soil, and production with nutrient and moisture limitations.

Practical

- Simulation of elementary models for crop growth
- Simulation of potential production
- Simulation with limitations of water and nutrient management options
- Sensitivity analysis using different climatic years and crop management practices

Suggested Readings

Gordan, G. 1992. *System Simulation(* 2nd Ed). Prentice Hall.

Kropff, M.J. and Vann Laar, H.H. (eds.). 1993. *Modelling Crop Weed Interactions*. ISBN.

Mathews, R.B, Kropff, M. J., Bachelet, D. and Vaan Laar, H.H. (eds.). 1993. *Modelling the Impact of Climate Change on Rice Production in Asia.* CABI. 75

Penning de Vries, F.W.T. and Van Laar, H,H. (eds.). 1982. *Simulation of Plant Growth and Crop Production*. Wageningen Centre for Agricultural Publications and Documentation, Netherlands.

Ritchie, J.T. and Hanks, J. 1991. *Modelling Plant and Soil Systems*. American Society of Agronomy, Madison.

Zeigler, B.P. 1976. *Theory of Modeling and Simulation*. John Wiley & Sons.

4. AGRON 604 ADVANCES IN CROP GROWH AND PRODUCTIVITY 2+1

Objective

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environment

Theory

UNIT I

Plant density and crop productivity-plant and environment factors, yield- plant distribution-strategies for maximizing solar energy utilization-leaf area, interception of solar radiation and crop growth; photosynthesis-photosynthetic apparatus, factors essential for photosynthesis, difference in photosynthetic rates among and within species-physiological limitations in crop yield-solar radiation concept and agro techniques for harvesting solar radiation

UNIT II

Growth analysis concept-CGR, RGR, NAR, LAI, LAD, LAR: validity and limitations in interpreting crop growth and development- Growth curves: sigmoid, polynomial and asymptotic- Growth expressions and Agrobiology -root systems- root-shoot relationship, principles involved in inter and mixed cropping systems under rainfed and irrigated conditions-concept and differentiation of inter and mixed cropping-criteria for assessing yield advantages- resource use efficiency in cropping systems

UNIT III

Competitive relationship and competition functions: biological and agronomic basis of yield advantage under intercropping- physiological principles of dry land crop production, constraints and remedial measures- heat unit concept of crop maturity.

UNIT IV

Correlation between yield and growth parameters- biometric observations of important crops- Management strategies to improve the growth parameters contributing to yield

UNIT V

Concept of plant ideotypes- characteristics of ideotype for wheat, rice, maize, etc.-use of growth hormones, their role in field crop production- efficient use of resources

Practical

- Field measurement of root- shoot relationship in crops of different growth stages
- Estimation of growth analysis parameters-CGR, RGR, NAR, LAI etc. at different stages of crop growth
- Growth expressions and calculations
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition indices-Aggressivity, RCC, LER, IER, Competition index etc. in intercropping
- Senescence and abscission indices
- Analysis of productivity trend in unirrigated areas
- Analysis of productivity trend in irrigated areas

Suggested Readings

Chopra, V.L. and Paroda, R.S. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants.* Oxford & IBH

Evans, L.T. 1975. *Crop Physiology*. Cambridge Univ. Press

Evans, L. T. 1996. *Crop Evolution, Adaptation and yield*. Cambridge Univ. Press

Gupta, U.S. (ed.).1995. *Production and Improvement of Crops for Drylands*. Oxford & IBH

Gupta, U.S. 1988. *Progress in Crop Physiology*. Oxford & IBH

Kramer P. J. and Boyer . J. S. 1995. *Water Relations of Plants and Soils.* Academic Press

Mukherjee, S. and Ghosh. 1996. *Plant Physiology*. Tata Mc Graw Hill

Narwal S.S , Politycka B. and Goswami, C.L. 2007. *Plant Physiology: Research Methods*. Scientific Publishers

Noggle, G. R. and Fritz, G. J. 1983. *Introductory Plant Physiology*. Prentice-Hall of India

5. AGRON 605 IRRIGATION MANAGEMENT 2+1

Objective

To teach students about optimization of irrigation in different crops under variable agro-climatic conditions.

Theory

UNIT I

Water resources of India, irrigation projects; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

UNIT II

Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

UNIT III

Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

UNIT IV

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

UNIT V

Crop water requirements- Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies, water use efficiency .

UNIT VI

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, Participatory irrigation management in command areas; irrigation legislation.

UNIT VII

Quality of irrigation water - Drainage of agricultural lands

Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles
- Moisture extraction pattern of crops
- Consumptive use, water requirement of a given cropping pattern for optimum/variable productivity
- Crop planning at the farm and project level • Agronomic evaluation of irrigation projects, case studies

Suggested Readings

FAO. 1984. *Irrigation Practice and Water Management.* Oxford & IBH.

Michael, A.M. 1978. *Irrigation: Theory and Practice*.Vikas Publ.

Mishra, R.R. and Ahmad, M. 1987. *Manual on Irrigation and Agronomy*. Oxford & IBH.

Panda, S.C. 2003. *Principles and Practices of Water Management*. Agrobios.

Reddy, S. R. 2000. *Principles of Crop Production*. Kalyani.

Sankara Reddy, G. H. and Yellamananda Reddy 1995. Efficient Use of Irrigation Water.

Gupta, U.S. (ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.

Singh, S.S. 2006. Principles and Practices of Agronomy. Kalyani

6. AGRON 606 ADVANCES IN WEED MANAGEMENT 2+0

Objective

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems

Theory

UNIT I

Crop weed competition in different cropping situations – changes in weed flora – various causes and effects

UNIT – II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action – selectivity of herbicides – factors affecting selectivity

UNIT – III

Factors affecting phytotoxicity of herbicides – fate of herbicides in soil – residue management

UNIT IV

Advances in herbicide application techniques – adjuvants and safeners – Compatibity of herbicides with other pesticides

UNIT – V

Development of transgenic herbicide resistant crops - Herbicide development - registration procedures – current status of herbicide use

UNIT – VI

Relationship of herbicides with tillage, fertilizers and irrigation.- bioherbicides-allelopathy as a tool for weed management., weed management in organic production systems – Role of biotechnology in weed management

Suggested Readings

Aldrich, R.J., Kramer, R.J. 1997. *Principles in Weed Management*. Panima publ.

Ashton, F.M and Crafts, A.S. 1981. *Mode of action of herbicides*(.2nd Ed). Wiley inter Science

Gupta,OP. 2007. *Weed management – Principles and Practices*. Agrobios

Mandal RC, 1990. *Weed, weedicides and weed control – Principles and Practices*. Agro – Botanical Publ.

Rao, VS. 2000. *Principles of Weed Science*. Oxford & IBH

Subramanian, S. Ali, AM and Kumar, RJ. 1997. All about weed control. Kalyani

Zimdahl RL. 1999. *Fundamentals of Weed Science* . 2nd Ed. Academic Press

7. AGRON 607 INTEGRATED FARMING SYSTEMS 2+0

Objective

To apprise about different enterprises suitable for different agroclimatic conditions for sustainable agriculture.

Theory

UNIT I

Farming systems: definition and importance; sustainability indices-LEIA, LEISA, HEIA classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

UNIT II

Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.

UNIT III

Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems through research; eco-physiological approaches to intercropping.

UNIT IV

IFS- Choice and size of Enterprise in IFS – IFS for different agro ecosystems-Resource allocation to different components in the system and its management Preparation of different farming system models; evaluation of different farming systems.

UNIT V

Farming system research for different situations - New concepts and approaches of farming systems and cropping systems - and organic farming; case studies on different farming systems. Interdisciplinary approach in FSR and Economics

Suggested Readings

Gangopadhyay, A. 2007 *Crop Production Systems and Management* Gene Tech.

Ananthakrishnan, T. N. (ed.) 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

Balasubramanian, P. and Palaniappan, S.P. 2006. *Principles and Practices of Agronomy*. Agrobios.

Francis, C. A..1986 *Multiple Cropping system* Mc Millon Publishing , NewYork

Joshi M and Parbhakarasetty, T.K. 2005. *Sustainability through Organic Farming*. Kalyani.

Lampkin, N. 1990. *Organic Farming*. Farming Press Books.

Palaniappan, S.P. and Anandurai, K. 1999. *Organic Farming - Theory and Practice*. Scientific Publ.

8. AGRON 608 SOIL CONSERVATION AND WATERSHED MANAGEMENT 2+1

Objective

To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach in watershed management.

Theory

UNIT I

Soil erosion: definition, nature and extent of erosion in India and Kerala- types of erosion, phases of erosion, factors affecting erosion, Tolerable soil limits- Universal soil loss equation (USLE) and its application**.** Research works undertaken at international, national and state level for controlling erosion. International, national and state level agencies and programmes for controlling erosion.

UNIT II

Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures - bunding, grading, trenching, gully control, check dams, terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts, estimating runoff –runoff coefficient, time of concentration

UNIT III

Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed management, delineation, codification, classification of watersheds, development of cropping systems for watershed areas- watershed management programmes in India.

UNIT IV

Land use capability classification, alternate land use systems; agro-forestry; ley farming; jhum management - basic concepts, socio-ethnic aspects, its layout.

UNIT V

Drainage considerations and agronomic management; rehabilitation of abandoned jhum lands and measures to prevent soil erosion and improve productivity of such lands

Practical

- Study of different types of erosion
- Field studies of different soil conservation measures
- Run-off and soil loss measurements
- Laying out run-off plot and deciding treatments
- Study of different agronomic methods like mulching, cover cropping, strip cropping etc. for soil erosion control
- Identification of different grasses and trees for soil conservation
- Visit to a soil conservation research centre, demonstration and training centre

Suggested Readings

Brooks, K.N., Ffolliott, P. F., Gregerson, H. M. and DeBano, L.F. 1997. *Hydrology and the Management of Watersheds* (2nd Ed.). Iowa State University Press, Ames.

De Barry, P.A. 2004. *Watersheds, Processes, Assessment and Management*. John Wiley and Sons, New Jersey.

Dhruvanarayana, V.V. 1993. *Soil and Water Conservation Research in India*. ICAR, New Delhi..

Frederick, F.R., Hobbs, J.A and Donahue, R.L. 1999. *Soil and Water Conservation: Productivity and Environmental Protection* (3rd Ed.). Prentice Hall, New Jersey.

Gurmel Singh, Venkataraman, C., Sastry, G. and Joshi, B.P. 1990. *Manual of Soil and Water Conservation Practices.* Oxford and IBH, New Delhi..

Murthy, V.V.N. 1995. *Land and Water Management Engineering*. Kalyani Publishers, Ludhiana.

Roose, E. 1996. *Land husbandry- Components and Strategy.* FAO soils bulletin No.70. Food and Agriculture Organization, Rome.

Schwab, G.O., Frevert, R. K., Edminster, T. W. and Barnes, K.K 1996. *Soil and Water Conservation Engineering* (4th Ed.). John Wiley and Sons, New York.

Sheng, T.C. 1989. *Soil Conservation for Small Farmers in the Humid Tropics*. FAO Soils Bulletin No. 60. Food and Agriculture Organization of the United Nations, Rome.

Sheng, T.C. 1990. *Watershed Management Field Manual. Watershed Survey and Planning*. FAO Conservation Guide 13/6. Food and Agriculture Organization of the United Nations, Rome.

Thomas, C.G. 2009. *Land Husbandry and Watershed Management*. Kalyani Publishers, Ludhiana.

Tripathi, R.P and Singh, H. P. 1993. *Soil Erosion and Conservation*. Wiley Eastern, New Delhi.

9. AGRON 609 STRESS CROP PRODUCTION 2+1

Objective

To study various types of stresses in crop production and strategies to overcome them.

Theory

UNIT I

Stress and strain terminology; nature and stress injury and resistance; causes of stress.

UNIT II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature tress through, soil and crop manipulations.

UNIT II

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

UNIT III

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

UNIT IV

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

UNIT V

Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

UNIT VI

Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

UNIT VII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

UNIT VIII

Light stress, effect on crop growth, ways to overcome the effect of light stress.

Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions

Suggested Readings

Baker, F.W.G.1989. *Drought Resistance in Cereals*. Oxon, UK.

Gupta, U.S. (ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.

Kramer, P.J.1983. *Water Relations of Plants*. Academic Press.

Levitt, J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.

Mavi, H.S.1978. *Introduction to Agro-meteorology*. Oxford & IBH.

Michael, A.M. and Ojha, T. P.1981. *Principles of Agricultural Engineering* Vol II. Jain Bros.
Nilsen, E.T and Orcut, D.M. 1996. *Physiology of Plants under Stress – Abiotic Factors.* John Wiley & Sons.
Singh, K. 2000. *Plant Productivity under Environmental Stress.* Agribios.
Singh, K.N. and Singh, R. P. 1990. *Agronomic Research Towards Sustainable Agriculture*. Indian Society of Agronomy, New Delhi.
Somani, L.L and Totawat, K.L. 1992. *Management of Salt-affected Soils and Waters.* Agrotech Publ.
Virmani, S.M., Katyal, J.C., Eswaran, H. and Abrol, I.P.1994. *Stressed Ecosystem and Sustainable Agriculture.* Oxford & IBH.

10. AGRON 610 ENVIRONMENTAL PROTECTION AND POLLUTION CONTROL 2+1

Objective

To give an overview on environmental pollution with special reference to agricultural operations and various measures to combat pollution.

Theory

UNIT I.

Environmental protection- importance- Sources of environmental pollution-Types of pollution-Impact of pollution-Agricultural pollution-

UNIT II

Agro chemicals and pollution-pollution from herbicides – Fate of Herbicides in soil – Decomposition : microbial, chemical and photodecomposition, Herbicide persistence – Methods to minimize herbicide residues – placement, herbicide rotation, crop rotation, trap crops, use of bugs for herbicide degradation. PP chemicals and pollution- safe limits in food products and natural resources

UNIT III

Herbicide toxicity problems to living organisms: Mammals, aquatic fauna, micro-organisms, shifts in weed flora – herbicide resistance development in weeds – history, reasons and prevention of resistance development. Herbicides in warfare – undesirable effects and health hazards-

UNIT IV

Nutrient sources and pollution – unfavorable effects on soil fertility and soil microbes-Agronomic management of environmental pollution – Agroforestry practices. Use of aquatic weeds for water purification. Siltation and sedimentation of reservoirs and lakes – Eutrophication – reasons and control measures.

UNIT V

Climate change-Global warming- Green house effect- Carbon sequestration- Ozone depletion-.

Practical

- Assessment and analysis of ecological degradation and sources of degradation in agricultural lands
- Collection water samples and analysis of quality parameters
- Assessment of biodiversity of flora and fauna
- Visit to Pollution Control Board and collection of information related to pollution in Kerala.

- Visit to Environmental Science Lboratories of reputed Institutes and familiarization of activities.

Suggested Readings

Hodges, L. 1977. *Environmental Pollution*. Holt, Rinehart and Winston, New York

Rana, S.V.S. 2005. *Essentials of Ecology and Environmental Science* (2nd ed.) Prentice-Hall of India, New Delhi.

Sharma, B.K. 2003. *Environmental Chemistry* (7th ed.). Goel Publishing House, Meerut

Tripathi A.K., Srivastava, A.K, and Pandey, S.N. 1993, *Advances in Environmental Sciences.*

Walker, C. 1975. *Environmental Pollution by Chemicals*. Anchor Press, Essex

Wright, R.T. 2007. *Environmental Science.* India Pvt Ltd. New Delhi

REMEDIAL COURSES FOR NON- AGRICULTURAL PG STUDENTS

1.AGRON 001. PRINCIPLES OF AGRONOMY 2+1

Objective

To give an introduction on various agronomic principles to non-agricultural students admitted for various PG Programmes

Theory

UNIT I

Agriculture-scope in India and Kerala-Agriculture as an art, science and business-Branches of agriculture - Agronomy and relationship with other disciplines-Agricultural seasons in India and Kerala.

UNIT II

Classification of crops- Agronomic classification of crops- Growth and factors affecting growth - Seed–definition - characteristics of good quality seed – methods of sowing/planting

UNIT III

Tillage- definition- objectives – types of tillage- tillage implements – tilth - characteristics of good tilth

UNIT IV

Soil productivity and fertility- Crop nutrition – nutrients –classification – Nutrient sources- organic manures –fertilizers – biofertilizers- Integrated Nutrient Management-

UNIT V

Irrigation and drainage- methods of irrigation- Importance of soil and water conservation- Watershed management as a part of natural resource management.

UNIT VI

Weed management- important weeds- methods of weed control- Herbicides- Integrated weed management-

UNIT VII

Cropping systems- Major farming systems- Farming Systems approach- Rainfed and irrigated agriculture.

Practical

- Visit to crop museum and identification of crops
- Study of tillage implements -ploughs, harrows and cultivators-
- Study of seeding equipments.

- Different methods of sowing- direct seeding: broadcasting, dibbling and drilling-transplanting
- Identification of manures and fertilizers-organic manures: bulky and concentrated-fertilizers: straight, complex and mixed fertilizers
- Fertilizer recommendation and calculation of doses for rice, coconut, cassava, and banana.
- Identification of important weeds
- Study different herbicide formulation
- Visit to experimental plots to study design and layout
- Yield estimation of crops.

Suggested Readings

Balasubramaniyan, P and Palaniappan, S.P.. 2001. *Principles and Practices of Agronomy*. AgroBios(India)Ltd., Jodhpur.
Brady, N.C. and Well, R.R. 2002. *The Nature and Properties of Soils* (13th ed.). Pearson Education, Delhi.
De, G.C.1989. *Fundamentals of Agronomy*. Oxford & IBH Publishing Co., New Delhi.
Havlin, J. L., Beaton, J. D., Tisdale, S.L., and Nelson, W.L. 2006. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management* (7thed.). Pearson Education, Delhi.
ICAR.2006. *Hand book of Agriculture*, ICAR, New Delhi.
Reddy. T.Y and Reddy, G.H.S.1995. *Principles of Agronomy*, Kalyani Publishers, Ludhiana.
Reddy.S.R.1999. *Principles of Agronomy*, Kalyani Publishers, Ludhiana.
Sankaran, S. and Subbiah Mudaliar, V.T. 1991.*Principles of Agronomy.* The Bangalore Printing & Publishing Co., Bangalore

2. AGRON 002 CROP PRODUCTION 2+1

Objectives

To give an overall view on all important field crops grown in India to non-agricultural students

Theory

Economic importance, soil and climatic requirement, varieties, cultural practices, harvest and post harvest handling, and value addition of the following crops:

UNIT I
Cereals (Rice, wheat, maize, sorghum)
UNIT II
Tuber crops (cassava, potato, sweet potato, yams, and aroids)
UNIT III
Fodder crops (guinea grass, hybrid napier, para grass, congo signal, stylo and subabul)
UNIT IV
Pulses (chick pea, cowpea, black gram, green gram, and red gram)
UNIT V
Oilseeds (groundnut and sesame); sugarcane and cotton.

Practical

- Identification and familiarisation of cereals, tuber crops, fodder crops, pulses, oilseeds, sugarcane and cotton

- Preparation of wet, dry and mat nurseries for rice
- Calculations on seed rate and fertilizer requirements
- Preparation of planting material of major crops
- Land preparation and planting, after cultivation operations
- Growth and yield measurements
- Harvesting, computation of cost of cultivation

Suggested Readings

Agarwal, P.C. 1990. *Oilseeds in India*. Oxford and IBH, New Delhi

Chidda Singh, Prem Singh and Rajbir Singh.2003. *Modern Techniques of Raising Field Crops* (2nd ed.). Oxford & IBH , New Delhi.

Das, P.C. 1997. *Oilseed Crops of India,* Kalyani Pub., New Delhi.

ICAR [Indian Council of Agricultural Research].2006. *Hand Book of Agriculture*. ICAR, New Delhi

KAU [Kerala Agricultural University].2007. *Package of Practices Recommendations – Crops*. Directorate of Extension, Kerala Agricultural University, Thrissur

Onwueme.I.C. and Charles. W.D . 1994. *Tropical Root and Tuber Crops – Production, Perspective and Future Prospects*. F.A.O. Production and Protection Paper-126, Rome.

Prasad, R (ed.). 2002. *Text Book of Field Crop Production*. ICAR.

Thomas, C. G. 2008. *Forage Crop Production in the Tropics* (2nd ed.). Kalyani Publishers, Ludhiana

List of Journals

- Advances in Agronomy
- agriculture, Ecosystems and Environment
- Agricultural systems
- Agricultural Water Management
- Agronomy Journal
- Annual Review of Plant Physiology
- Applied Ecology and Environment Research
- Australian Journal of Agricultural Research
- Australian Journal of Experimental Agriculture
- Crop Protection
- Environment and Ecology
- European Journal of Agronomy
- Fertilizer Research
- Field Crops Research
- Indian Journal of Agricultural Sciences
- Indian Journal of Agronomy
- Indian Journal of Ecology
- Indian Journal of Weed Science
- Irrigation Science
- Japanese Journal of Crop Science
- Journal of Agronomy
- Journal of Applied Ecology
- Journal of Experimental Botany
- Journal of Farming Systems Research
- Journal of Range Management
- Journal of Agricultural Science Cambridge

- Journal of Sustainable Agriculture
- Netherlands Journal of Agricultural Science
- Nutrient Cycling in Agro ecosystems
- Pesticide Biochemistry and physiology
- Plant and Soil
- Plant Production Science
- Soil and Tillage Research
- Swedish Journal of agricultural Research
- Tropical Agriculture
- Weed Research

Suggested Broad Topics for Master's and Doctoral Research

- Crop diversification under different agricultural situations
- Development of farming systems for marginal, small and other farmers
- Agricultural information at door step/click of mouse
- Farm-specific nutrient management
- Weed management in different cropping farming systems
- Nutrient studies in different cropping/farming systems
- Biodiversity of farming systems for conservation
- Organic farming systems for different regions
- Modeling for different crop situations
- Conservation agriculture for yield sustainability
- Role of edaphic factors on weed proliferation and management
- Implications of global warming on weed growth and herbicide behaviour
- Ecological implications of using thresholds for weed management
- Effect of cultivation practices and herbicides on weed flora shift.
- GM crop and weed management strategies
- Weed management under reduced moisture regime in major summer/*kharif* crops
- Avoidance of herbicide resistance using IWM.
- Agro waste and industrial waste utilization
- Advanced technologies for enhancing water use efficiency of crops
- Water Management strategies for cropping systems
- Agro technologies for soil and water conservation
- Resource optimization for crop production
- Impact of climate change on crop production
- Crop production in problem soils.
- Standardization of tillage requirement in cropping systems
- Agro techniques for Eco-restoration.
- Bio-remediation for natural resource conservation and utilization

II SOIL SCIENCE

COURSE STRUCTURE – AT A GLANCE

CODE COURSE	TITLE	CREDITS
SOILS 501*	SOIL PHYSICS	2+1
SOILS 502*	SOIL FERTILITY AND FERTILIZER USE	3+1
SOILS 503*	SOIL CHEMISTRY	2+1
SOILS 504*	SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY	2+1
SOILS 505	SOIL EROSION AND CONSERVATION	2+1
SOILS 506*	SOIL BIOLOGY AND BIOCHEMISTRY	2+1
SOILS 507	GEOMORPHOLOGY AND GEOCHEMISTRY	2+0
SOILS 508	RADIOISOTOPES IN SOIL AND PLANT STUDIES	1+1
SOILS 509	SOIL, WATER AND AIR POLLUTION	2+1
SOILS 510	REMOTE SENSING AND GIS TECHNIQUES FOR SOIL AND CROP STUDIES	2+1
SOILS 511	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	1+2
SOILS 512	SYSTEM APPROACHES IN SOIL AND CROP STUDIES	2+1
SOILS 513	MANAGEMENT OF PROBLEMATIC SOILS AND WATERS	2+1
SOILS 514	FERTILIZER TECHNOLOGY	1+0
SOILS 515	LAND DEGRADATION AND RESTORATION	1+0
SOILS516	PLANT BIOCHEMISTRY	2+1
SOILS 517	INTRODUCTION TO AGROCHEMICALS	2+0
SOILS518	SOIL HEALTH MANAGEMENT	1+1
SOILS 519	BASIC BIOCHEMISTRY	2+1
SOILS 520***	INTRODUCTION TO SOILS	2+1
SOILS 591	MASTER'S SEMINAR	0+1
SOILS 599	MASTER'S RESEARCH	20
	PhD programme	
SOILS 601	ADVANCES IN SOIL PHYSICS	2+0
SOILS 602 **	ADVANCES IN SOIL FERTILITY	2+0
SOILS 603**	PHYSICAL CHEMISTRY OF SOILS	2+0
SOILS 604	SOIL GENESIS AND MICROPEDOLOGY	2+0
SOILS 605 **	BIOCHEMISTRY OF SOIL ORGANIC MATTER	1+1
SOILS 606	LAND USE PLANNING AND WATERSHED MANAGEMENT	2+0
SOILS 691	DOCTORAL SEMINAR I	0+1
SOILS 692	DOCTORAL SEMINAR II	0+1
SOILS 699	DOCTORAL RESEARCH	40

*Compulsory for Master's programme

** Compulsory for PhD. programme

*** Remedial course for MSc (Agricultural Statistics)

1.SOILS 501 SOIL PHYSICS 2+1

Objective

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory

UNIT I

Scope of soil physics and its relation with other branches of soil science; soil as a three phase system.

UNIT II

Soil texture, textural classes, mechanical analysis, specific surface.

UNIT III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts.

UNIT IV

Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

UNIT V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

UNIT VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

UNIT VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continue.

UNIT IX

Composition of soil air; - characteristics, Oxidation- Reduction Potential- ODR-renewal of soil air - convective flow and diffusion;-measurement of soil aeration; aeration requirement for plant growth; soil air management.

UNIT X

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

- Mechanical analysis by pipette and international methods Measurement of Soil Physical properties
- Measurement of Atterberg limits
- Aggregate analysis - dry and wet
- Measurement of soil-water content by different methods
- Measurement of soil-water potential by using tensiometer and gypsum blocks
- Determination of soil-moisture characteristics curve and computation of pore-size distribution
- Determination of hydraulic conductivity under saturated and unsaturated conditions
- Determination of infiltration rate of soil
- Determination of aeration porosity and oxygen diffusion rate

• Soil temperature measurements by different methods
• Estimation of water balance components in bare and cropped fields

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
Ghildyal BP & Tripathi RP. 2001. *Soil Physics*. New Age International.
Hanks JR & Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.
Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.
Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.
Hillel D. 1998. *Environmental Soil Physi*cs. Academic Press.
Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.
Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
Kohnke H. 1968. *Soil Physics*. McGraw Hill.
Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
Oswal MC. 1994. *Soil Physics*. Oxford & IBH.
Saha AK. 2004. *Text Book of Soil Physics*. Kalyani.

2.SOILS 502 SOIL FERTILITY AND FERTILIZER USE 3+1

Objective

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

UNIT I

Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms.

UNIT II

Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation - types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

UNIT III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions.—Skipping of Phosphatic fertilizers.

UNIT IV

Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

UNIT V

Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

UNIT VI

Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

UNIT VII

Common soil test methods for fertilizer recommendations; quantity– intensity relationships; soil test crop response correlations and response functions.

UNIT VIII

Fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management.

UNIT IX

Fertilizer plants and processes in India-with different feed stocks used-future thrust-Global and Indian requirement of NPK- future projections

UNIT X

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

- Principles of colorimetry
- Flame-photometry and atomic absorption spectroscopy
- Chemical analysis of soil for CEC-root CEC, total and available nutrients
- Analysis of plants for essential elements

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed.Pearson Edu.

Kabata-Pendias A & Pendias H. 1992. *Trace Elements in Soils and Plants*.CRC Press.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *BiofertilizersTechnology*. Scientific Publ.

Leigh JG. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.

Mengel K & Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

Pierzinsky GM, Sims TJ & Vance JF. 2002. *Soils and Environmental Quality.* 2nd Ed. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon,Nitrogen,Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.

Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility andFertilizers.* 5th Ed. Prentice Hall of India.

Troeh FR & Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

Wild Soil conditions and plant growth

3.SOILS 503 SOIL CHEMISTRY 2+1

Objective

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

UNIT I

Chemical (elemental) composition of the earth's crust and soils.

UNIT II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

UNIT III

Soil colloids:- Goldschmidt's law of crystal chemistry-, inorganic and organic colloids - principles of silicate clay structure ,origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation /flocculation and peptization of soil colloids; electrometric properties of soil colloids;

sorption properties of soil colloids;- -relative stability of clay minerals, soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions & Metal Organic Complexes

UNIT IV

Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermo dynamics, statistical mechanics; anion and ligand exchange – innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange. AEC, CEC; Ion exchange system in humid tropical soils-experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

UNIT V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects.

UNIT VI

Chemistry of acid soils; active and potential acidity; lime potential, Al and MN toxicity; sub-soil acidity.Liming materials and its action.

UNIT VII

Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

UNIT VIII

Chemistry and electrochemistry of submerged soils.

Practical

• Determination of CEC and AEC of soils

• Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH, meter and conductivity meter • Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method • Potentiometric and conductometric titration of soil humic and fulvic acids • (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the Δ (E4/E6) values at two pH values

• Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm

• Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved

• Determination of titratable acidity of an acid soil by BaCl2-TEA method

• Determination of lime requirement of an acid soil by buffer method

• Determination of gypsum requirement of an alkali soil

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil.* Oxford and IBH.

Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.

Greenland DJ & Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.

McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford Univ. Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.
Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.
Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.
Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
Tan, K. H. 1982. Principles Of Soil Chemistry
Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

4. SOILS 504 SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY 2+1

Objective

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

UNIT I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

UNIT II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils.

UNIT III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.-Geological formation of India and Kerala.

UNIT IV

Concept of soil individual; soil classification systems – early and modern systems of soil classification historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

UNIT V

Soil survey and its types; collection soil resource Inventory Data -soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations-survey report & soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps.

UNIT VI

Landform – soil relationship; major soil groups of India and Kerala with special reference to recent classification of Kerala soils by NBSS & LUP ; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Practical

- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available data base in terms of soil quality

• Aerial photo and satellite data interpretation for soil and land use
• Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
• Land use planning exercises using conventional and RS tools

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
Dixon JB & Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.
Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.
I. A. R.I 1970 Soil Survey Mannual
Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.
USDA. 1999. *Soil Taxonomy*. Hand Book No**.** 436. 2nd Ed. USDA NRCS, Washington.
Wade FA & Mattox RB. 1960. *Elements of Crystallography andMineralogy*. Oxford & IBH.
Wilding LP & Smeck NE. 1983. *Pedogenesis and Soil Taxonomy*: II. *TheSoil Orders*. Elsevier.
Wilding NE & Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I.*Concept and Interaction*. Elsevier.

5. SOILS 505 SOIL EROSION AND CONSERVATION 2+1

Objective

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

UNIT I

History, distribution, identification and description of soil erosion problems in India.

UNIT II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

UNIT III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

UNIT IV

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

UNIT V

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

UNIT VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed

management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical

• Determination of different soil erodibility indices - suspension percentage, dispersion ratio,
erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility
index
• Computation of kinetic energy of falling rain drops
• Computation of rainfall erosivity index (EI30) using rain gauge data
• Visits to a watersheds

Suggested Readings

Biswas TD & Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.
Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990. *Manual ofSoil and Water Conservation Practices*. Oxford & IBH.
Hudson N. 1995. *Soil Conservation*. Iowa State Univ. Press.
Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS,New Delhi.
Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

6. SOILS 506 SOIL BIOLOGY AND BIOCHEMISTRY 2+1

Objective

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UNIT I

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora.

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV

Organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

UNIT V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

UNIT VI

Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Practical

• Determination of soil microbial population

• Soil microbial biomass
• Elemental composition, fractionation of organic matter and functional groups
• Soil enzymes
• Measurement of important soil microbial processes such as ammonification, nitrification, N2
fixation, S oxidation, P solubilization and mineralization of other micro nutrients
• Study of rhizosphere effect

Suggested Readings

Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.
Burges A & Raw F. 1967. *Soil Biology*. Academic Press.
McLaren AD & Peterson GH. 1967. *Soil Biochemistry*. Vol. XI. Marcel Dekker.
Metting FB. 1993. *Soil Microbial Ecology – Applications in Agriculturaland Environmental Management*. Marcel Dekker.
Paul EA & Ladd JN. 1981. *Soil Biochemistry*. Marcel Dekker.
Reddy MV. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.
Russel RS. 1977. *Plant Root System: Their Functions and Interaction withthe Soil*. ELBS & McGraw Hill.
Stotzky G & Bollag JM. 1993. *Soil Biochemistry.* Vol. VIII. Marcel Dekker.
Sylvia DN. 2005. *Principles and Applications of Soil Microbiology* Pearson Edu.
Wild A. 1993. *Soil and the Environment - An Introduction*. Cambridge Univ. Press.

7. SOILS 507 EOMORPHOLOGY AND GEOCHEMISTRY 2+0

Objective

To impart knowledge about the landforms, physiography and morphology of the earth surface, and distribution and weathering elements in the earth crust.

Theory

UNIT I

General introduction to geology and geochemistry, major and minor morphogenic and genetic landforms, study of schematic landforms and their elements with special reference to India.

UNIT II

Methodology of geomorphology, its agencies, erosion and weathering; soil and physiography relationships; erosion surface of soil landscape.

UNIT III

Geochemical classification of elements; geo-chemical aspects of weathering and migration of elements; geochemistry of major and micronutrients and trace elements.

Suggested Readings

Brikland PW. 1999. *Soils and Geomorophology*. 3rd Ed. Oxford Univ.Press.
Likens GE & Bormann FH. 1995. *Geochemistry*. 2nd Ed. Springer Verlag.
Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

8.SOILS 508 ADIOISOTOPES IN SOIL AND PLANT STUDIES 1+1

Objective

To train students in the use of radioisotopes in soil and plant research

Theory

UNIT I

Atomic structure, radioactivity and units; radioisotopes - properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter

UNIT II

Principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography

UNIT III

Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

UNIT IV

Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

- Storage and handling of radioactive materials
- Determination of half life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes
- Determination of A, E and L values of soil using 32P/ 65Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of 15N enrichment by mass spectrophotometery/ emission spectrometry

Suggested Readings

Comer CL. 1955. *Radioisotopes in Biology and Agriculture: Principles and Practice*. Tata McGraw Hill.

Glasstone S. 1967. *Source Book on Atomic Energy*. East West Press.

Michael FL & Annunziata. 2003. *Handbook of Radioactivity Analysis*. Academic Press.

9. SOILS 509 SOIL, WATER AND AIR POLLUTION 2+1

Objective

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

UNIT I

Soil, water and air pollution problems associated with agriculture, nature and extent.

UNIT II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings.

UNIT III

Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal.

UNIT IV

Pesticides – their classification, behavior in soil and effect on soil microorganisms-biodegradation of pesticides

UNIT V

Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

UNIT VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide.

UNIT VIII

Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

• Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants

• Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents

• Heavy metals in contaminated soils and plants

• Management of contaminants in soil and plants to safeguard food safety

• Air sampling and determination of particulate matter and oxides of sulphur

• Visit to various industrial sites to study the impact of pollutants on soil and plants

Suggested Readings

Lal R, Kimble J, Levine E & Stewart BA. 1995. *Soil Management and Greenhouse Effect.* CRC Press.

Middlebrooks EJ. 1979. *Industrial Pollution Control*. Vol. I. *Agro- Industries*. John Wiley Interscience.

Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.

Vesilund PA & Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.

10 SOILS 510 REMOTE SENSING AND GIS TECHNIQUES FOR SOIL AND CROP STUDIES 2+1

Objective

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

Theory

UNIT I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter.- scanners remote sensing platforms & satellites;

UNIT II

Sensor systems –camera, microwave radiometers and fundamentals of aerial photographs and image processing and interpretations.

UNIT III

Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management.

UNIT IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.- Maps, Images, Aerial photographs and data scanners.

UNIT V

-Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical

• Familiarization with different remote sensing equipments and data products
• Interpretation of aerial photographs and satellite data for mapping of land resources
• Analysis of variability of different soil properties with classical and geostatistical techniques
• Creation of data files in a database programme
• Use of GIS for soil spatial simulation and analysis
• To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed.
Pearson Edu.

Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.

Lillesand TM & Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.

Nielsen DR & Wendroth O. 2003. *Spatial and Temporal Statis*tics. Catena Verloggmbh.

Star J & Esles J. 1990. *Geographic Information System: An Introduction*.Prentice Hall.

11. SOILS 511 ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS 1+2

Objective

To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Theory

UNIT I

General principles of Analytical chemistry-introduction to volumetric analysis-Acidimetry-Alkalimetry-Redox reactions-Complexometry-Precipitation reactions – Gravimetry Introduction to instrumental methods of analysis-Potentiometry-Conductometry

UNIT II

Specrtal methods of Analysis-Colorimetry Spectrophotometry- turbidimetry Nephelometry

UNIT III

Emission spectroscopy-Flame photometry-Plasma emission spectroscopy Atomic absorption spectrophotometry-Hollow cathode lamps-multi element lamps-electrodeless dischargelamps-

UNIT IV

X ray diffraction- Differential thermal analysis-Chromatography-partition, column,paper,Thin, Gas, Gas-Liquid, HPLC- Principles and insrumentation

Practical

UNIT I

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

UNIT II

Importance of instrumental analysis in Agriculture and Allied Science-Potentiometry-measurement of pH- Conductometry – Measurement of EC

UNIT III

Principles of visible, ultraviolet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry;

UNIT IV

chromatographic techniques.Mass spectrometry-X ray diffractometry-Identification of minerals .

Suggested Readings

Hesse P. 971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.

Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.

Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*.Marcel Dekker.

Kenneth Helrich 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.

Page AL, Miller RH & Keeney DR. 1982. *Methods of Soil Analysis*. Part II.SSSA, Madison.

Piper CE. *Soil and Plant Analysis*. Hans Publ.

Singh D, Chhonkar PK & Pandey RN. 1999. *Soil Plant Water Analysis - AMethods Manual*. IARI, New Delhi.

Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.

Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Wat*ers.FDCO, New Delhi.

Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

SOILS 512 SYSTEM APPROACHES IN SOIL AND CROP STUDIES 2+1

Objective

To train the students in concepts, methodology, technology and use of systems simulation in soil and crops studies.

Theory

UNIT I

Systems concepts - definitions, general characteristics; general systems theory; systems thinking, systems dynamics, systems behavior and systems study.

UNIT II

Model: definition and types; mathematical models and their types; modeling: concepts, objectives, processes, abstraction techniques; simulation models, their verification and validation, calibration; representation of continuous systems simulation models - procedural and declarative.

UNIT III

Simulation - meaning and threats; simulation experiment, its design and analysis.

UNIT IV

Application of simulation models in understanding system behavior, optimizing system performance, evaluation of policy options under different soil, water, nutrient, climatic

and cultural conditions; decision support system, use of simulation models in decision support system.

Practical

• Use of flow chart or pseudo-code in the program writing

• Writing a small example simulation model program - declarative (in Vensim PLE, Stella or Simile) and procedural (in Java, Fortran, QBasic or V Basic)

• Conducting simulation experiments in DSSAT, WOFOST or EPIC with requirement of report and conclusion

Suggested Readings

Benbi DK & Nieder R. (Eds.). 2003. *Handbook of Processes anModelling in the Soil - Plant System*. Haworth Press.

Hanks J & Ritchie JT. (Eds.). 1991. *Modelling Plant and Soil System. Agronomy***.** Bull. No 31. Soil Sci. Society of America, Madison.

Rajaraman V. 2004. *Computer Programming in Fortran 90 and 95*. PHI.

Tsuji GY, Gerrit H & Philip T. 1998. *Understanding Options for Agricultural Production.* Kluwer.

von Bertalanffy Ludwig 1969. *General Systems Theory: Foundation Development and Application*. Revised Ed. George Braziller Reprint 1998.

Web sites

oDocumentation of the respective models. (http://www.simulistics.com/for Simile; http://www.iseesystems.com for Stella; and http://www.vensim.com/software.html for vensim PLE)

- http://www.icasa.net/dssat/index.html for DSSAT; http://www.brc.tamus.edu/epic/ for EPIC
- http://www.nrel.colostate.edu/projects/century/ for Century
- http://www.alterra.wur.nl/NL/for WOFOST
- http://www.apsru.gov.au/ apsru/Default.htm for APSIM
- http://eco.wiz.uni-kassel.de/ecobas.html online Register of ecological models
- Plentinger MC Penning de Vries FWT, Editors (1996) CAMASE Register of Agro-ecosystems Models. DLO-Research Institute for Agrobiology and Soil Fertility (AB-DLO)
- Agricultural Systems – Elsevier at http://www.elsevier.com/wps/product/cws_home /405851
- Ecological Modeling – Elsevier at http://www.elsevier.com/locate/ecolmodel

13. SOILS 513 MANAGEMENT OF PROBLEMATIC SOILS AND WATERS 2+1

Objective

To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

Theory

UNIT I

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible**.**

UNIT II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties.

UNIT III

Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.

UNIT IV

Acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils Morphology of acid saline soils-Chemistry and nutrient changes in relation to submergence. management of acid soil with special ref to management of problem soil of Kerala. biological sickness of soils and its management.

UNIT V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

UNIT VI

Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

• Characterization of acid, acid sulfate, salt-affected and calcareous soils • Determination of cations (Na+, K+, Ca++ and Mg++) in ground water and soil samples • Determination of anions (Cl-, SO4 --, CO3 -- and HCO3 -) in ground waters and soil samples

• Lime and gypsum requirements of acid and sodic soils

Suggested Readings

Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.

Jurinak JJ. 1978. *Salt-affected Soils*. Department of Soil Science & Biometeorology. Utah State Univ.

Padmaja, P. Problem soils of Kerala.

USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.

Varghese T. Laterite Soils

14. SOILS 514 FERTILIZER TECHNOLOGY 1+0

Objective

To impart knowledge about how different fertilizers are manufactured using different kinds of raw materials and handling of fertilizers and manures.

Theory

UNIT I

Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states;.

UNIT II

Manufacturing processes for different fertilizers using various raw materials, characteristics and nutrient contents.

UNIT III

Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order.

UNIT IV

New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, supergranules fertilizers .

UNIT V

Fertilizer legislation, Fertilizer control order and its Implementation, packing requirements in relation to storage & determination, specifications of fertilizers.

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils.* Pearson Edu.

Fertilizer (Control) Order, 1985 and the Essential Commodities Act. FAI New Delhi.

Kanwar JS. (Ed.). 1976. *Soil Fertility: Theory and Practice*. ICAR.

Olson RA, Army TS, Hanway JJ & Kilmer VJ. 1971. *Fertilizer Technology and Use.* 2nd Ed. Soil Sci. Soc. Am. Madison.

Prasad R & Power JF. *Soil Fertility Management for SustainableAgriculture*. CRC Press.

Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility andFertilizers.* McMillan Publ.

Vogel AI. 1979. *Textbook of Quantitative Inorganic Analysis*. ELBS.

15.SOILS 515 LAND DEGRADATION AND RESTORATION 1+0

Objective

To impart knowledge related to various factors and processes of land degradation and their restoration techniques.

Theory

UNIT I

Type, factors and processes of soil/land degradation and its impact on soil productivity, including soil fauna, biodegradation and environment.

UNIT II

Land restoration and conservation techniques - erosion control, reclamation of salt-affected soils; mine land reclamation, afforestation, organic products.

UNIT III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Suggested Readings

Biswas TD & Narayanasamy G. (Eds.). 1996. *Soil Management in Relation to Land Degradation and Environment. Bull. Indian Soc. Soil Sci.*, New Delhi.

Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.

Greenland DJ & Szabolcs I. 1994. *Soil Resilience and Sustainable LandUse*. CABI.

Lal R, Blum WEH, Vailentine C & Stewart BA. 1997. *Methods for Assessment of Soil Degradation.* CRC Press.

Sehgal J & Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

16. SOILS 516 PLANT BIOCHEMISTRY 2+1

Objective

Detailed information about biochemical and molecular basis of various plant processes and plant growth regulatory substances.

Theory

UNIT I

Scope and importance of biochemistry in Agriculture, Plant cell organelles and their separation, structure and function of cell organelle. Photosynthetic pigments in relation to their functions, photosynthesis, C3, C4 and CAM pathways, photorespiration.

UNIT II

Sucrose-starch interconversion, biosynthesis of structural carbohydrates, storage proteins and lipids. Biochemistry of nitrogen fixation and nitrate assimilation, sulphate reduction and incorporation of sulphur in to amino acids.

UNIT III

Biochemistry of seed germination and development, Biochemistry of fruit ripening, phytohormones and their mode of action, signal transduction.

UNIT IV

Biochemistry and significance of secondary metabolites-cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids, plant defense system.

Practical

Analysis of plant samples
Estimation of proximate constituents Ca, Mg and trace elements
Estimation of carbohydrates – Proteins – oils and fats, crude fibres –
Analysis of sugars in cane juice –
Assessment of quality of feed and forage crops –
Estimation of sugars, vitamin in fruits and vegetables –
Estimation of alkaloids and tannin
Estimation of toxin in feeds and forage crops
Tissue test – Identification of deficiency and toxicity symptoms.

Suggested Readings

Buchanan BB, Gruissem W & Jones RL. 2000. *Biochemistry andMolecular Biology of Plants.* 2nd Ed. John Wiley.
Dey PM & Harborne JB. 1997. *Plant Biochemistry*. Academic Press.
Goodwin TW & Mercer EI. 1983. *Introduction to Plant Biochemistry*.Pergamon Press.
Heldt HS. 1997. *Plant Biochemistry and Molecular Biology*. Oxford Univ.Press.
Lea PJ & Leegood RC. 1993. *Plant Biochemistry and Molecular Biology*.2nd Ed. John Wiley.

17. SOILS 517 INTRODUCTION TO AGROCHEMICALS 2+0

Objective

To give an overview of pesticides with reference to their classification,structure, mode of action, synthesis and formulations and pesticide residue analysis.

Theory

UNIT I

Definition, IUPAC approved terminology, statistics of production and consumption. Classification, plant production chemicals - an overview, nitrification regulators, soil conditioners, chemical hybridizing agents, hydrogels, seed coats etc. fertilizer control

order. Plant protection chemicals: Pesticides – classification (both synthetic and natural),
Insecticides Act.

UNIT II

History of botanical insecticides, structure, properties, mode of action and uses of conventional insecticides such as nicotine, pyrethrins and rotenones. Insect antifeedants and growth regulators including Drimane sesquiterpenoids, withanilides, clerodanes, quassinoids and limonoids, hormone analogues (JH, anti-JH, JH-mimics, moulting hormones), Semiochemicals - pheromones and allelochemicals.

UNIT III

Structure, properties, mode of action and uses of synthetics: Insecticides- chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids and others (ex neo-nicotinoids). Fungicides - inorganic, organic- heterocyclic, formamide, alkane, alkane carboxylic acid and miscellaneous groups. Strobilurin fungicides and antibiotics.Nematicides - aliphatic halogen compounds, methyl isocyanate liberators, organophosphates and carbamates.

UNIT IV

Formulation of pesticides - definition, classification, objectives, process, product development. Formulation codes, conventional formulations such as EC, WP, Dust, Granule etc. Pesticide adjuvants: synergists**.**

UNIT V

Pesticide residue: Concept definition, significance and analysis as per BIS specifications, Agrochemicals in water, soil, air and non-target organism status, impact, monitoring, etc.

Suggested Readings

Baker DR, Fenyes JG & Steffens JJ. (Eds.). 1992. *Synthesis and Chemistry of Agrochemicals.* Vols. I-III. ACS Symposium Series 504, ACS Washington D.C.

Buchel KH. (Ed.). 1992. *Chemistry of Pesticides.* John Wiley & Sons.

Hassal K. 1982. *The Chemistry of Pesticides*. The Macmillan Press.

Marrs TC & Bryan BT. (Eds.). 2004. *Pesticide Toxicology and International Regulation*. John Wiley & Sons.

Murayama T. 1987. *Japan Pesticide Information*. Japan Plant Protection Association, Tokyo.

Parmar BS & Tomar SS. 2004. *Pesticide Formulation: Theory & Practice*.CBS Publ.

Roberts HA. (Ed.). 1982. *Weed Control Handbook: Principles.* BlackwellScientific Publ.

Tomar SS & Parmar BS. 1992. *Dictionary of Agricultural Chemicals*.Academic India Publ.

Handa SK 2004. *Principles of Pesticide Chemistry*. Agrobios.

18. SOILS 518 SOIL HEALTH MANAGEMENT (1+1)

Objective:- to impart knowledge about soil health and its management in sustainable agriculture.

UNIT I

Siol quality concept-inherent and dynamic soil quality-soil health-Definitions-Land quality- Functional approaches-components of soil quality –soil quality/s air and water quality-Soil degradation physical-chemical-biological factors conservation practices

UNIT II

Essential services provided by Soil- Nutrient cycling-Organic recycling-Organic matter-humus-soil food web –water Relations biodiversity and Habitat-filtering and Buffering-Physical Stability and support Soil quality and Agricultural sustainability

UNIT III

Soil quality characters-Indicators of soil quality-Non Quantitative- quantitative-Chemical –Physical Biological –Assessment of soil health- Assessment as a monitoring tool-Lab based assessments –Concept of minimum data set –indicator selection-interpreting indicators-multifactor sustainability-sustainability index-Indexing soil quality-Soil quality test kits-Soil health card

UNIT IV

Management practices-Sustainablity and soil health management-history and importance of organic matter management- Soil organic carbon conservation and sequestration-Characterisation of soil carbon pools under different land use management systems-Soil quality and resilience in relation to SOC pools

UNIT V

Tools and techniques to build soil health- Biological methods of improving nutrient use efficiency-Biological nitrogen fixation- Biological phosphorus mobilization/solubilization- microbial inoculants for plant growth promotion-Biofertilizer technology- green manures,green leaf manures- Composting-vermicomposting- nutrient enriched manures- quality standards for organic manures-large scale compost production-Scope of land use management on carbon trading- Soil bioremediation- Nutrient management – Integrated pest management- Organic farming and soil health.

Practical

Soil Health assessment-

Estimation of important physical properties of soil

Estimation of important chemical properties of soil

Estimation of important biological properties of soil

Determination of Soil Quality indices

Preparation of Soil Health card

Evaluation of quality standards of different organic manures

Suggested Readings

Das P.C 1993 Manures & Fertilizers, Kalyani Publishers , New Delhi

Sharma A.K 2005 Biofertilizers for Sustainable Agriculture Published by Agrobios India, Jodhpur

Tandon H.L.S 1992 Fertilizers, Organic manures,Recyclable wastes and Biofertilizers, Fertilizer development and consultation organization.pp148

Tendon H.L.S 1993.Methods of analysis of soils, Plants, Water and Fertilizers, Fertilizer development and consultation organization .pp 143

19. SOIL 519 BASIC BIOCHEMISTRY 2+1

Objective

To provide elementary knowledge/overview of structure, functions and metabolism of biomolecules.

Theory

UNIT I

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen

bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids.

UNIT III

Structure and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action.

Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

UNIT IV

Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology, Nutritional aspects of carbohydrates, lipids, proteins and minerals.

Practical

i. Preparation of standard and buffer solutions.
ii. Extraction and estimation of sugars and amino acids.
iii. Estimation of proteins by Lowry's method.
iv. Estimation of DNA and RNA by Diphenyamine and orcinol methods.
v. Estimation of ascorbic acid.
vi. Separation of biomolecules by TLC and paper chromatography

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outlines of Biochemistry*. John Wiley.
Metzler DE. *Biochemistry.* Vols. I, II. Wiley International.
Nelson DL & Cox MM. 2004. *Lehninger's Principles of Biochemistry*.MacMillan.
Voet D & Voet JG. *Biochemistry*. 3rd Ed. Wiley International.

20 SOILS 520 INTRODUCTION TO SOILS 2+1

Objective

To provide elementary knowledge about soils, fertility and plant nutrition.

Theory:

UNIT I

Soil-Pedological and edaphological concepts -origin of the earth - earth's crust - composition. Rocks and minerals. Weathering - soil formation - factors and processes - components of soils -soil profile.

UNIT II

Soil physical properties - soil texture - textural classes - particle size analysis. Soil structure Classification - soil aggregates – significance. Soil consistency - soil crusting. Bulk density and particle density of soils and porosity - their significance and manipulation. Soil compaction

UNIT III

Soil Colour. Elementary knowledge of soil classification. Soils of India - geological formations – characterization of soils of Kerala.

UNIT IV

Soil water - retention and potentials - soil moisture constants - movement of soil water infiltration – percolation – permeability – drainage - methods of determination of soil moisture. Thermal properties of soils - soil temperature - soil air - gaseous exchange influence of soil temperature and air on plant growth.

UNIT V

Soil colloids – properties – nature - types and significance. Adsorption of ions - ion exchange CEC and AEC - factors influencing ion exchange and its significance. Concept of pH Soil acidity - brief overview of saline, sodic and calcareous soils. Reclamation of problemsoils Soil organic matter – composition –. Carbon cycle - C: N ratio. Soil biology – biomass – soil organisms and their beneficial and harmful roles.

UNIT VI

Soil Fertility – nutrients of importance- availability of nutrients to plants – soil conditions favorable for plant growth- management of Plant Nutrition – Manures – fertilizers- Biological N fixation – Biofertilisers- Integrated Nutrient management- Pollution from Agricultural lands -Concept of organic farming.

Practical

i. Determination of bulk density and particle density - aggregate analysis – soilstrength

ii. Soil moisture determination - soil moisture constants – field capacity - infiltration rate –

water holding capacity.

iii. Soil texture and mechanical analysis. Soil temperature

iv.Analytical chemistry – basic concepts - techniques and calculations.

v.Collection and processing of soil for analysis – organic carbon, pH, EC, -

vi. Study of a soil profile – Identification of rocks and minerals.

vii Estimation of CEC,- soil fertility evaluation .

Suggested Readings

Biswas, T.D. and Mukherjee, S.K. 1987. *Text Book of Soil Science.* Tata McGraw Hill Publishing Co., New Delhi

Brady, N.C. 1990. *Nature and Properties of Soils*. 10th Edn, Macmillian Publishing Co. Inc., New York

Foth, H.D. and Turk, L. M. 1972. *Fundamental of Soil Science*. 5th Edn. Wiley Eastern Pvt. Ltd., New Delhi

Gupta, P.K. 2007. Soil, Plant, Water and Fertilizer Analysis. Published by AGROBIOS (India), Jodpur

Jaiswal, P.C. 2006. *Soil, Plantand Water Analysis*. 2nd Edn. Kalyani Publishers, ludhiyana

Das.D.K, 1997. *Introductory Soil Science*. Kalyani Publishers, New Delhi.

Ph.D COURSES

1. SOILS 601 ADVANCES IN SOIL PHYSICS 2+0

Objective
To provide knowledge of modern concepts in soil physics.
Theory
UNIT I
Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system.
UNIT II
Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow.
UNIT III
Theories of horizontal and vertical infiltration under different boundary conditions.
UNIT IV
Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through
curves.
UNIT V
Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil.
UNIT VI
Soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soils conditioners - types, characteristics, working principles, significance in griculture.
UNIT VII
Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.
Suggested Readings
Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
Hanks and Ascheroft. 1980. *Applied Soil Physics*. Springer Verlag.
Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
Hillel D. 1980. *Environmental Soil Physi*cs. Academic Press.
Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS,New Delhi.
Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley Interscience.
Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
Oswal MC.1994. *Soil Physics*. Oxford & IBH.

2. SOILS 602 ADVANCES IN SOIL FERTILITY 2+0

Objective
To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

UNIT I

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices.

UNIT II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

UNIT III

Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils.

UNIT IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

UNIT V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

UNIT VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Suggested Readings

Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.

Barker V Allen & Pilbeam David J. 2007. *Handbook of Plant Nutrition*. CRC / Taylor & Francis.

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed.Pearson Educ.

Cooke GW. 1979. *The Control of Soil Fertility*. Crossby Lockwood &Sons.

Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives*.International Potash Institute, Switzerland.

Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC / Taylor & Francis.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technolo*gy. Scientific Publ.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991. *Micronutrients in Agriculture.* 2nd Ed. Soil Science Society of America, Madison.

Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen,Phosphorus, Sulphur, Micronutrients.* John Wiley & Sons.

Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.

Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1990. *Soil Fertility and Fertilizers.* 5th Ed. Macmillan Publ.

Wild A. (Ed.). 1988. *Russell's Soil Conditions and Plant Growth*. 11th Ed.Longman

3. SOILS 603 PHYSICAL CHEMISTRY OF SOILS 2+0

Objective

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

Theory

UNIT I

Colloidal chemistry of inorganic and organic components of soils – their formation, clay organic interaction.

UNIT II

Predictive approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer.

UNIT III

Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction.

UNIT IV

Adsorption/desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

UNIT V

Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil.* Oxford & IBH.
Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
Fried M & Broeshart H. 1967. *Soil Plant System in Relation to InorganicNutrition.* Academic Press.
Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
Greenland DJ & Hayes MHB. 1978. *Chemistry of Soil Constituents*. John Wiley & Sons.
Jurinak JJ. 1978. *Chemistry of Aquatic Systems*. Dept. of Soil Science & Biometeorology, Utah State Univ.
McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford Univ. Press.
Sparks DL. 1999. *Soil Physical Chemistry*. 2nd Ed. CRC Press.
Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.
Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.
Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.
Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.
van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

4. SOILS 604 SOIL GENESIS AND MICROPEDOLOGY 2+0

Objective

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

UNIT I

Pedogenic evolution of soils; soil composition and characterization.

UNIT II
Weathering and soil formation – factors and pedogenic processes; stability and weathering sequences of minerals.
UNIT III
Assessment of soil profile development by mineralogical and chemical analysis.
UNIT IV
Micro-pedological features of soils – their structure, fabric analysis, role in genesis and classification.

Suggested Readings

Boul SW, Hole ED, MacCraken RJ & Southard RJ. 1997. *Soil Genesis and Classification.* 4th Ed. Panima Publ.
Brewer R. 1976. *Fabric and Mineral Analysis of Soils.* John Wiley & Sons

5. SOILS 605 BIOCHEMISTRY OF SOIL ORGANIC MATTER 1+1

Objective

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

UNIT I
Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter
pools.
UNIT II
Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.
UNIT III
Nutrient transformation – N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.
UNIT IV
Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.
UNIT V
Humus - pesticide interactions in soil, mechanisms.

Practical

Estimation of soil organic matter - comparison of different methods.
Extraction of humus - Using different extractants
Fractionation of humus - Spectroscopic studies in characterization
Fractionation of Soil N - total organic N, amino-N, amino-sugar N, hydrolysable N - Analysis of various functional groups.

Suggested Readings

Beck AJ, Jones KC, Hayes MHB & Mingelgrin U. 1993. Organic *Substances in Soil and Water: Natural Constituents and their*
Influences on Contaminant Behavior. Royal Society of Chemistry,London.
Gieseking JE. 1975. *Soil Components*. Vol. 1. *Organic Components*.Springer-Verlag.
Kristiansen P, Taji A & Reganold J. 2006. *Organic Agriculture: A GlobalPerspective.* CSIRO Publ.
Magdoff F & Weil RR 2004. *Soil Organic Matter in SustainableAgriculture*. CRC Press.

Mercky R & Mulongoy K. 1991. *Soil Organic Matter Dynamics andSustainability of Tropical Agriculture.* John Wiley & Sons.
Paul EA. 1996. *Soil Microbiology and Biochemistry*. Academic Press.
Stevenson FJ. 1994. *Humus Chemistry – Genesis, Composition andReactions.* John Wiley & Sons.

6. SOILS 606 LAND USE PLANNING AND WATERSHED MANAGEMENT 2+0

Objective

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

UNIT I

Concept and techniques of land use planning; factors governing present land use.

UNIT II

Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

UNIT III

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production.

UNIT IV

Water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity.

UNIT V

Watershed development/management - concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Suggested Readings

All India Soil and Land Use Survey Organisation 1970. *Soil Survey Manual*. IARI, New Delhi.
FAO. 1976. *A Framework for Land Evaluation*, Handbook 32. FAO.
Sehgal JL, Mandal DK, Mandal C & Vadivelu S. 1990. *Agro-Ecological Regions of India*. NBSS & LUP, Nagpur.
Soil Survey Staff 1998. *Keys to Soil Taxonomy*. 8th Ed. USDA & NRCS, Washington, DC.
USDA 1974. *A Manual on Conservation of Soil and Water Handbook of Professional Agricultural Workers*. Oxford & IBH.

SOIL SCIENCE

List of Journals

- Advances in Agronomy
- Annals of Arid Zone
- Australian Journal of Agricultural Research
- Australian Journal of Soil Research
- Biology and Fertility of Soils
- Communications in Soil Science and Plant Analysis
- Clays and Clay minerals
- European Journal of Soil Science

• Geoderma
• Indian Journal of Agricultural Sciences
• Journal of Plant Nutrition and Soil Science
• Journal of the Indian Society of Soil Science
• Nutrient Cycling in Agroecosystems
• Plant and Soil
• Soil and Tillage Research
• Soil Biology and Biochemistry
• Soil Science
• Soil Science Society of America Journal
• Soil Use and Management
• Water, Air and Soil Pollution
• Water Resources Research
Tropical Agriculture
Madras Agricultural Journal
Mysore Agricultural Journal

Suggested Broad Topics for Master's and Doctoral Research

• Degradation and restoration of soil as natural resource
• Biochemistry of processes at the soil-root interface
• Impact of current agricultural practices and agrochemicals on soil quality/biodiversity
• Integrated nutrient management for sustainable agriculture
• Fertilizer use efficiency in different soil conditions/cropping systems
• Use of remote sensing and GIS as diagnostic tool for natural resource management
• Role of biological agents in soil productivity
• Modeling solute (salt, fertilizer, pesticides) transport in soil
• Use of poor quality waters in Agriculture
• Soil testing and crop response
• Site-specific nutrient management and precision agriculture
• Nutrient dynamics in soil-plant system and modeling nutrient uptake
• Tillage and crop residue management in crop production
• Utilization of urban and industrial wastes/effluents in Agriculture
• Management of problematic soils
• Impact of climate change on soil processes
• Micronutrients in soil, plant and human health
• Water management strategies in different cropping systems
• Simulation models for growth and production of different crops
• Varietals response to soil salinity/ sodicity/ nutrients/ pollutants, etc
• Soil and water pollution - monitoring and control
• Genesis, formation and classification of soils
• Soil conservation, preservation and management for sustainable agriculture
• Remediation of polluted and contaminated soils

III AGRICULTURAL METEOROLOGY

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
AGM 501*	FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY	2+1
AGM 502*	FUNDAMENTALS OF AGRICULTURAL METEOROLOGY	2+1
AGM.503*****	MICROMETEOROLOGY	2+1
AGM 504*****	AGRO-METEOROLOGICAL MEASUREMENTS AND INSTRUMENTATION	1+2
AGM 505	SOIL WATER BALANCE CLIMATOLOGY	2+1
AGM 506	CROP WEATHER MODELS	1+2
AGM 507	WEATHER MODIFICATION AND RISK MANAGEMENT STRATEGIES	2+0
AGM 508	PRINCIPLES OF REMOTE SENSING AND ITS APPLICATIONS IN AGRICULTURE	2+1
AGM 509	APPLIED AGRICULTURAL CLIMATOLOGY	1+2
AGM 591	MASTER'S SEMINAR	1+0
AGM 599	MASTER'S RESEARCH	20
AGM 510	CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT	2+1
AGM 511	ADVANCES IN AGROCLIMATOLOGY	2+1
AGM 512	WEATHER, CLIMATE AND LIVESTOCK	2+1

*Compulsory for Master's programme

1.AGM 501 FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY 2+1

Objective

To impart theoretical and practical knowledge of physical processes occurring in atmosphere and techniques used in meteorology.

Theory

UNIT I

Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation of pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anticyclonic motions; geostropic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.

UNIT II

Gas laws, laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, saturationdeficit, stability and instability conditions in the atmosphere.

UNIT III

Lapse rates-ascent of dry and moist air, condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes, artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.

UNIT IV

Effect of earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind; the trade winds, equatorial trough and its movement; the SE Asia monsoon.

UNIT V

Crop weather charts, calenders and diagrams; weather forecasting importance, types, tools, and modern techniques of weather forecasting; El Nino, la Nino and ENSO.

UNIT VI

Instruments for measurement of meteorological elements; Agromet observatory; measures of central tendency and dispersion, correlation, regression, moving average probability and their distribution function; water budgeting; synoptic, numerical, graphical, spatial analysis of weather systems and charts technique.

Practical

- Agromet observatory- different classes of observatories (A, B, C)
- Site selection and installation procedures for meteorological instruments
- Measurement of weather parameters.
- Reading and recording, calculation of daily, weekly, monthly means.
- Totals of weather data.
- Climatic normals, weather chart preparation and identification of low pressure systems and ridges.
- Statistical technique for computation of normals, moving average, marton chain model etc.

Suggested Readings

Barry RG & Richard JC. 2003. *Atmosphere, Weather and Climate*. Tailor & Fransics Group.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Ghadekar SR. 2001. *Meteorology.* Agromet Publ.

Mcllveen R. 1992. *Fundamentals of Weather and Climate*. Chapman & Hall.

Petterson S. 1958. *Introduction to Meteorology*. McGraw Hill.
Rao, GSLHVP. 2008. Agricultural Meteorology, PHI Learning Pvt Ltd., New Delhi
Rao, GSLHVP, Rao, GGSN, Rao, VUM and Ramakrishna YS. 2008. Climate Change and Agriculture over India. KAU-ICAR Publication.
Trewartha Glenn T. 1954. *An Introduction to Climate*. McGraw Hill.

2. AGM 502 FUNDAMENTALS OF AGRICULTURAL METEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of physical processes occurring in relation to plant and atmosphere with advanced techniques.

Theory

UNIT I

Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.

UNIT II

Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.

UNIT III

Crop weather calendars; weather forecasts for agriculture at short, medium and long range levels; agromet advisories, preparation, dissemination and economic impact analysis; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.

UNIT IV

Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.

UNIT V

Meteorological aspects of forest fires and their control; concepts of mechanistic and deterministic models; general features of dynamical and statistical modeling techniques; weather data and phenology-based approaches to crop modeling; validation and testing of models.

UNIT VI

Climatic change, green house effect, CO2 increase, global warming and their impact on agriculture; concept and types of drought; climate classification, agro-climatic zones and agro-ecological regions of India.

Practical

- Preparation of crop weather calendars.
- Development of simple regression models for weather, pest and disease relation in different crops.
- Preparation of weather based agro-advisories.
- Use of automated weather station (AWS)

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Kakde JR. 1985. *Agricultural Climatology*. Metropolitan Book Co.
Varshneya MC & Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

3. AGM 503 MICROMETEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of physical processes occurring in lower atmosphere.

Theory

UNIT I

Properties of atmosphere near the earth's surface; exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficient, similarity hypothesis, shearing stress, forced and free convection**.**

UNIT II

Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; temperature instability, air pollution; microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth; Richardson number, Raymonds analogy, Exchange coefficients.

UNIT III

Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; modification of microclimate due to cultural practices, intercropping; radiation distribution and utilization by plant communities, leaf temperature and its biological effects; influence of topography on microclimate; shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates; instruments and measuring techniques in micrometeorology.

UNIT IV

Effects of ambient weather conditions on growth, development and yield of crops; measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces; net radiation measurement at different levels; PAR distribution in plant canopies and interception; wind, temperature and humidity profiles in (a) short crops and (b) tall crops; energy balance over crops and LAI and biomass estimation; remote sensing in relation to micrometeorology.

Practical

- Micrometerological measurements in crop canopies
- Quantification of crop microclimate
- Determination of ET and its computation by different methods

Suggested Readings

Arya S Pal. 1988. *Introduction to Micrometeorology*. Academic Press.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Gates DM. 1968. *Energy Exchange in the Biosphere*. UNESCO.

Goudriaan J. 1983. *Crop Micrometeorology: A Simulation Study*. Scientific Publ.

Grace J. 1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.

Gupta PL & Rao VUM. 2000. *Practical Manual on Micrometeorology*. Dept. of Agril. Meteorology, CCS HAU Hisar, India.

Jones HG. 1992. *Plants and Micriclimate*. Cambridge Univ. Press.

Munn RE. 1970. *Biometeorological Methods*. Academic Press.

Rosenberg NJ. 1974. *Microclimate – The biological Environmet*. John Wiley & Sons.

Sellers W. 1967. *Physical Climatology*. The University of Chicago Press.

4.AGM 504 AGRO-METEOROLOGICAL MEASUREMENTS AND INSTRUMENTATION 1+2

Objective

To impart the theoretical and practical knowledge of instruments/equipments used for measurement of agro-meteorological variables.

Theory

UNIT I

Fundamentals of measurement techniques; theory and working principles of barometers, thermometers, psychrometers, hair hygrometer, thermohygrograph; exposure and operation of meteorological instruments/equipments in agromet observatories.

UNIT II

Radiation and temperature instruments: working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, dew recorder, quantum radiation sensors, pressure bomb apparatus, thermographs, and infra-red thermometer.

UNIT III

Precipitation and dew instruments: working principles of rain gauge, self recording rain gauge, Duvdevani dew gauges.

UNIT III

Wind instruments: working principles of anemometer, wind vane, anemograph.

UNIT IV

Evapotranspiration and photosynthesis instruments: working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area meter.

UNIT V

Soil thermometers, soil heat flux plates, instruments for measuring soil moisture.

UNIT VI

Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.

Practical

- Working with the above instruments in the meteorological observatory taking observations of relevant parameters.
- Computation / interpretation of the data

Suggested Readings

Anonymous. 1987. *Instructions to Observers at Surface Observatories*. Part I, IMD, New Delhi.

Byers HR. 1959.*General Meteorology*. McGraw Hill.

Ghadekar SR. 2002. *Practical Meteorology: Data Acquisition Techniques, Instruments and Methods*. Agromet Publ.

Middleton WE & Spilhaws AF. 1962. *Meteorological Department*. University of Toronto Press.

Rao, GSLHVP. 2008. Agricultural Meteorology, PHI Learning Pvt Ltd., New Delhi

Rao, GSLHVP, Rao, GGSN, Rao, VUM and Ramakrishna YS. 2008. Climate Change and Agriculture over India. KAU-ICAR Publication.

Tanner CB. 1973. *Basic Instrumentation and Measurements for Plant Environment and Micrometeology*. University of Wisconsin, Madison.

5.AGM 505 SOIL WATER BALANCE CLIMATOLOGY 2+1

Objective

To impart the theoretical and practical knowledge of ET estimation and measurements.

Theory

UNIT I

Basic Laws of radiation; radiation interaction with plant environment; energy balance in atmosphere, crop canopy.

UNIT II

Atmosphere near the ground; laminar and turbulent flows; wind profile near the ground.

UNIT III

Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration - modified techniques.

UNIT IV

Influence of microclimatic, plant, soil and cultural factors; techniques of lysimetry in measuring actual evapotranspiration.

UNIT IV

Yield functions; water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and antitranspirants, Kc values and their use, dry matter yield ET functions; radiation instruments; advanced techniques for measurement of radiation and energy balance; computation of KC values and their use; estimation of evapotranspiration through satellite imageries – MODIS, TERRA, AQUA, AVHRR, NOVA etc.; modeling for potential ET & reference ET, and ET through remote sensing.

Practical

- Measurement and evaluation of radiation components
- Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods
- Measurement of wind and temperature profiles near the ground

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Burman R & Pochop LO. 1994. *Evaporation, Evapotranspiration and Climatic Data*. Elsevier.

Grace J.1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.

Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture.* The Haworth Press.

Murthy VRK. 2002. *Basic Principles of Agricultural Meteorology*. BS Publ.

Ram Niwas, Diwan Singh & Rao VUM. 2000. *Pratical Manual on Evapotranspiration*. Dept. of Agril. Meteorology, CCS HAU Hisar.

Rosenberg NJ, Blad BL & Verma SB. 1983. *Microclimate – The Biological Environment*. John Wiley & Sons.

6. AGM 506 CROP WEATHER MODELS 1+2

Objective

To impart the theoretical and practical knowledge of various models for estimation of crop weather responses.

Theory

UNIT I

Principles of crop production; evaluation of crop responses to weather elements; impact of natural and induced variability of climate on crop production.

UNIT II

Empirical and statistical crop weather models their application with examples; regression models- incorporating weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models; crop simulation models, e. g. CERES, WOFOST, SPAW, RESCAP, WTGROW etc.; forecasting of pests and diseases; verification, calibration and validation of models.

Practical

- Working with statistical and simulation models, DSSAT models, BRASSICA, RESCAP etc.

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

DeWit CT, Brouwer R & de Vries FWTP. 1970. The Simulation of Photosynthetic Systems. pp. 7-70. In. *Prediction and Measurement of Photosynhetic Activity*. Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC. Wageningen.

Duncan WG. 1973. SIMAI- A Model Simulating Growth and Yield in Corn. In: *The Application of Systems Methods to Crop Production* (D.N. Baker, Ed.). Mississippi State Univ. Mississipi.

Frere M & Popav G. 1979. *Agrometeorological Crop Monitoring and Forecasting*. FAO.

Hanks RJ. 1974. Mode for Predicting Plant Yield as Influenced by Water Use. *Agron. J.* 66: 660-665.

Keulen H Van & Seligman NG. 1986. *Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop.* Simulation Monographs. PUDOC, Wageningen.

7. AGM 507 WEATHER MODIFICATION AND RISK MANAGEMENT STRATEGIES 2+0

Objective

To impart the theoretical and practical knowledge of weather modification techniques with risk management strategies.

Theory

UNIT I

Historical reviews of weather modification, present status of weather modification for agriculture; atmospheric composition and green house effect.

UNIT II

Theories of weather modification; scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.

UNIT III

Risks in agricultural production, history of weather and climate as accepted risk factors in agriculture in the continent/region/country/sub-region concerned and the related documented risk concepts; history and trends of defense strategies towards such risks in the same continent region/country/sub-region; preparedness for weather and climate risks.

UNIT IV

Risks of droughts; monitoring, prediction and prevention of drought; drought proofing and management; modern tools inlcuidng remote sensing and GIS in monitoring and combating droughts.

UNIT VI

Risk characterization - definitions and classification of risks; characterization of weather and climate related risks in agriculture; water related risks; radiation/heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.

UNIT VII

Approaches and tools to deal with risks - history of methods for weather and climate related risk assessments in the continent/region/country/subregion concerned and their documented evidence of application to agricultural/farming systems; strategies of dealing with risks- mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.

UNIT VIII

Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information; heterogeneity of rural people in education, income, occupation and information demands and consequences for risk information products and their transfer; livelihood-focused support, participation and community perspectives; challenges for developing coping strategies including transferring risks through insurance schemes.

UNIT IX

Challenges to coping strategies - combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses, basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer; quantification of risk in agricultural systems associated with weather and climate; methods for risk assessment and application to agricultural systems of local and regional interest; application of risk management approaches to problems associated with weather and climate problems; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

Suggested Readings

Anonymous 2003. *Critical Issues in Weather Modification Research Board of Atmoshperic Science and Climate*. National Research Council, USA.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Chritchfield HJ. 1994. *General Climatology*. Prentice Hall.

Lenka D. 1998. *Climate, Weather and Crops in India*. Kalyani.

Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture.* The Haworth Press.

Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH. Menon PA. 1989. *Our Weather*. National Book Trust.

Pearce RP. 2002. *Meteorology at the Millennium*. Academic Press.

Rao, GSLHVP. 2008. Agricultural Meteorology, PHI Learning Pvt Ltd., New Delhi

Rao, GSLHVP, Rao, GGSN, Rao, VUM and Ramakrishna YS. 2008. Climate Change and Agriculture over India. KAU-ICAR Publication.
Rosenberg NJ, Blad BL & Verma SB. 1983. *Microclimate – The Biological Environment.* John Wiley & Sons.
Samra JS, Pratap Narain, Rattan RK & Singh SK. 2006. *Drought Management in India*. Bull. Indian Society of Soil Science 24, ISSS, New Delhi.

8.AGM 508 PRINCIPLES OF REMOTE SENSING AND ITS APPLICATIONS IN AGRICULTURE 2+1

Objective

To impart the theoretical and practical knowledge of remote sensing principles and their use to estimate of agro-meteorological variables.

Theory

UNIT I

Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.

UNIT II

Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions.

UNIT III

Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance.

UNIT IV

Data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction.

UNIT V

Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

UNIT VI

Digital techniques for crop discrimination and identification; crop stress detection - soil moisture assessment, inventory of ground water and satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation.

UNIT VII

Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting.

Practical

- Acquisition of maps
- Field data collection
- Map and imagery scales
- S/W and H/W requirements and specifications for remote sensing
- Data products, their specifications, media types, data inputs, transformation, display types, image enhancement
- Image classification methods
- Evaluation of classification errors
- Crop discrimination and acreage estimations
- Differentiation of different degraded soils
- Time domain reflectometry
- Use of spectrometer and computation of vegetation indices

- Demonstration of case studies
- Hands on training

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Colwell RN. (Ed.*). Manual of Remote Sensing*. Vols. 1, II. Am. Soc. Photogrammetry, Virginia.
Curan PJ. *Principles of Remote Sensing*. ELBS/Longman.
Georg Joseph 2005. *Fundamentals of Remote Sensing*. University Press (India).
Jain AK. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall of India.
Narayan LRA. 1999. *Remote Sensing and its Applications*. Oscar Publ.
Patel AN & Surender Singh 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

9.AGM 509 APPLIED AGRICULTURAL CLIMATOLOGY 1+2

Objective

To impart the theoretical and practical knowledge of computation of different bio-parameters and their applications in the agriculture.

Theory

UNIT I

Climatic statistics: measures of central tendency and variability, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.

UNIT II

Hydrological cycle: precipitation intensity, evaporation, infiltration, runoff, soil storage and hydrological balance.

UNIT III

Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications; assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.

UNIT IV

Thermal indices and phenology: cardinal temperatures; heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; crop weather calendars; agroclimatic requirement of crops.

UNIT V

Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

Practical

- Use of statistical approaches in data analysis
- Preparation of climatic water budget
- Estimation of agro-meteorological variables using historical records
- Degree day concept and phenology forecasting and preparation of crop calendar
- Evaluation of radiation, wind and shading effects in site selection and orientation
- Study of weather-pest and disease interactions, calculation of continentality factors; calculation of comfort indices and preparation of climograph.

Suggested Readings

Anonymous 1980. *ICRISAT Climatic Classification – A Consultation Meeting*. ICRISAT.
Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Lal DS. 1989. *Climatology*. Chaitanya Publ. House.
Mather JR. 1977. *Work Book in Applied Climatology*. Univ. of Delware, New Jersey.
Mavi HS & Tupper Graeme J. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
Raj Singh, Diwan Singh & Rao VUM. 2006. *Manual on AppliedAgricultural Climatology*. Dept of Agril Meteorology, CCS HAU, Hisar, India.
Rao, GSLHVP. 2008. Agricultural Meteorology, PHI Learning Pvt Ltd., New Delhi
Rao, GSLHVP, Rao, GGSN, Rao, VUM and Ramakrishna YS. 2008. Climate Change and Agriculture over India. KAU-ICAR Publication.
Subramaniam VP. 1977. *Incidence and Spread of Continental Drought*. WMO/IMD Report No. 2, WMO, Geneva, Switzerland.
Thompson R. 1997. *Applied Climatology: Principles and Practice*. Routledge.
Walter J Saucier 2003. *Principles of Meteorological Analysis*. Dover Phoenix Eds.

10. AGM 510 CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT 2+1

Objective

To impart the theoretical and practical knowledge of climate change and their sources.

Theory

UNIT I

Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, ozone depletion; past records, present trends, extreme weather events and future projections; astronomical predictions: lunar cycle, sunspot cycle, soil-lunar tides, Chandlers compensation, blocking highs.

UNIT II

Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security; hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems; human health; human settlements, energy, and industry; insurance and other financial services; climate change and crop diversification, loss of biodiversity, microbes and pest dynamics; climate change and storage, climate change and weed management.

UNIT III

Sensitivity, adaptation and vulnerability: system's sensitivity, adaptive capacity and vulnerability to climate change and extreme weather events; regional scenarios of climate change and variability.

UNIT IV

Mitigation strategies for sustainable development: international policies, protocols, treaties for reduction in greenhouse gases and carbon emissions; carbon sequestration; carbon credit; clean development mechanism (CDM) and land use, land use change and forestry mechanism, alternate energy sources etc.

UNIT V

Agricultural food security: reduction in carbon and GHG emission; fuel conservation and reduction in energy use, conservation tillage, biofuels for fossil fuels, reduction in machinery use etc; increasing carbon sinks; resource conservation technologies, mixed

rotations of cover and green manure crops, minimization of summer fallow and no ground cover periods etc.

Practical

- Case studies on various climatic projections and consequences thereof in relation to agriculture
- Advance methodology of assessing the impact of climate change on crops

Suggested Readings

Anonymous. *Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol*. UNEP, UNDP Publ.

Anonymous. *IPCC Assessment Reports on Climate Change (2001, 2007).* WMO, UNEP Publ.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Jepma CJ & Munasinghe M. 1998. *Climate Change Policy: Facts, Issues and Analysis*. Cambridge Univ. Press.

Mintzer IM. 1992. *Confronting Climate Change: Risks, Implications and Responses.* Cambridge Univ. Press.

Pretty J & Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex.

Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.

Rao, GSLHVP. 2008. Agricultural Meteorology, PHI Learning Pvt Ltd., New Delhi

Rao, GSLHVP, Rao, GGSN, Rao, VUM and Ramakrishna YS. 2008. Climate Change and Agriculture over India. KAU-ICAR Publication.

Salinger J, Sivkumar MVK & Motha RP. 2005. *Increasing Climate Variability of Agriculture and Forestry*. Springer.

Sinha SK. 1998. *Dictionary of Global Climate Change*. Commonwealth Publ.

11.AGM 511 ADVANCES IN AGROCLIMATOLOGY 2+1

Objective

To impart the theoretical and practical knowledge of computation of different bio-parameters and their applications in the agriculture.

Theory

UNIT I

Climatic statistics: measures of central tendency and variability, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.

UNIT II

Hydrological cycle: precipitation intensity, evaporation, infiltration, runoff, soil storage and hydrological balance.

UNIT III

Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications; assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.

UNIT IV

Thermal indices and phenology: cardinal temperatures; heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; crop weather calendars; agroclimatic requirement of crops.

UNIT V

Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

Practical

- Use of statistical approaches in data analysis
- Preparation of climatic water budget
- Estimation of agro-meteorological variables using historical records
- Degree day concept and phenology forecasting and preparation of crop calendar
- Evaluation of radiation, wind and shading effects in site selection and orientation
- Study of weather-pest and disease interactions, calculation of continentality factors; calculation of comfort indices and preparation of climograph.

Suggested Readings

Anonymous 1980. *ICRISAT Climatic Classification – A Consultation Meeting*. ICRISAT.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Lal DS. 1989. *Climatology*. Chaitanya Publ. House.

Mather JR. 1977. *Work Book in Applied Climatology*. Univ. of Delware, New Jersey.

Mavi HS & Tupper Graeme J. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.

Raj Singh, Diwan Singh & Rao VUM. 2006. *Manual on AppliedAgricultural Climatology*. Dept of Agril Meteorology, CCS HAU, Hisar, India.

Rao, GSLHVP. 2008. Agricultural Meteorology, PHI Learning Pvt Ltd., New Delhi

Rao, GSLHVP, Rao, GGSN, Rao, VUM and Ramakrishna YS. 2008. Climate Change and Agriculture over India. KAU-ICAR Publication.

Subramaniam VP. 1977. *Incidence and Spread of Continental Drought*. WMO/IMD Report No. 2, WMO, Geneva, Switzerland.

Thompson R. 1997. *Applied Climatology: Principles and Practice*. Routledge.

Walter J Saucier 2003. *Principles of Meteorological Analysis*. Dover Phoenix Eds.

12.AGM 512 WEATHER, CLIMATE AND LIVESTOCK 2+1

Objective

To impart the theoretical and practical knowledge of weather, climate for livestock management.

Theory

UNIT I

Thermal balance in animals; energy exchange processes at the skin of the animals and the need for the maintenance of thermal balance in the animals.

UNIT II

Effects of weather on animal production, loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sun burns and photosensitive disorders.

UNIT III

Meteorological conditions prevailing in glass-house, green house, animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors.

UNIT IV

Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.

UNIT V

Management of livestock to reduce greenhouse gas emission.

Practical

- Measurement of temperature, humidity, net radiation
- Calculation of animal comfort zone index
- Radiation of animal farm house and body
- Estimation of enegy fluxes on body
- Measurements of CO2 and methane in animal farm house

Suggested Readings

Kaiser HM & Drennen TE. (Eds). 1993. *Agricultural Dimensions of Global Climate Change*. St. Lucie Press, Florida.

Monteith L & Unsworth M. 2007. *Principles of Environmental Physics*. 2nd Ed. Academic Press.

Takahashi J, Young BA, Soliva CR & Kreuzer M. 2002. *Greenhouse Gases and Animal Agriculture.* Proc. 1st International Conference on Greenhouse Gases and Animal Agriculture.

Tromp SW. 1980. *Biometeorology. The Impact of the Weather and Climate on Humans & their Environment. (Animals & Plants).* Heyden & Son Ltd.

List of Journals

- Agricultural and Forest Meteorology
- Agricultural Systems
- Agricultural Systems and Information Technology Newsletter
- Agronomy Journal
- Atmospheric Research
- Canadian Water Resource Journal, Ottawa
- Climate Dynamics
- Climate Research
- Climatic Change
- Computers and Electronics in Agriculture
- Crop Science
- Ecological Modelling
- Environmental Monitoring and Assessment
- GIS India
- Hydrology Journal
- Indian Journal of Environmental Protection
- International Journal of Climatology
- International Journal of Remote Sensing
- Italian Journal of Agrometeorology
- Journal of Agricultural Meteorology
- Journal of Agrometeorology
- Journal of Applied Meteorology
- Journal of Applied Hydrology
- Journal of Applied Meteorology and Climatology
- Journal of Earth Systems Science
- Journal of Hydrologic Engineering

- Journal of Hydrometeorology
- Journal of Weather Modification Association
- Mausam
- Monthly Climatological Data for the World
- Photonirwachak
- Pollution Research
- Remote Sensing of Environment
- Vatavaran
- Vayu Mandal
- Water Resource Research
- Weather
- Weather and Forecasting
- WMO Bulletin

IV PLANT BREEDING AND GENETICS

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
GP501*	PRINCIPLES OF GENETICS	2+1
GP502*	CELL BIOLOGY AND CYTOGENETICS	2+1
GP503*	PRINCIPLES OF PLANT BREEDING	2+1
GP504*	PRINCIPLES OF QUANTITATIVE GENETICS	2+1
GP505	MUTAGENESIS AND MUTATION BREEDING	2+1
GP506	POPULATION GENETICS	1+1
GP507	HETEROSIS BREEDING	1+1
GP508*	MOLECULAR GENETICS	2+1
GP509*	BIOTECHNOLOGY FOR CROP IMPROVEMENT	2+1
GP510	BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE	2+1
GP511	BREEDING CEREALS, FORAGES AND SUGARCANE	2+1
GP512	BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS	2+1
GP513	BREEDING FOR QUALITY TRAITS	1+1
GP514	GENE REGULATION AND EXPRESSION	2+0
GP515	MAINTENANCE BREEDING, CONCEPTS OF VARIETY RELEASE AND SEED PRODUCTION	1+1
GP 516@	GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE	2+1
GP 517	DATA BASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR	2+1
GP518	BREEDING FOR TROPICAL CROPS	1+1
GP519	INTELLECTUAL PROPERTY RIGHTS AND PLANT BREEDING	2+0
GP520***	GENETICS	2+0
GP591	MASTER'S SEMINAR	1+0
GP599	MASTER'S RESEARCH	0+20
	Ph D courses	
GP601	PLANT GENETIC RESOURCES AND THEIR UTILIZATION	2+0
GP602	ADVANCES IN QUANTITATIVE GENETICS	2+1
GP603**	GENOMICS IN CROP IMPROVEMENT	2+1
GP604**	MOLECULAR AND CHROMOSOMAL MANIPULATIONS IN CROP IMPROVEMENT	2+0
GP605**	ADVANCED PLANT BREEDING SYSTEMS	2+0
GP606	CROP-EVOLUTION	2+0
GP607	BREEDING DESIGNER CROPS	2+1
GP608	ADVANCES IN BREEDING OF MAJOR CROPS	3+0
GP609	MICROBIAL GENETICS	2+1
GP610@@	*IN SITU* AND *EX SITU* CONSERVATION OF GERMPLASM	2 +1
GP 691	DOCTORAL SEMINAR I	1+0
GP 692	DOCTORAL SEMINAR II	1+0
GP 699	DOCTORAL RESEARCH	45

**Compulsory for Master's programme*

**** only for Agricultural Statistics Students*

@Cross listed with SST 515

*** Compulsory for Ph. D. programme*

@@ Cross listed with SST 602

1.GP 501 PRINCIPLES OF GENETICS 2+1

Objective

This course is aimed at understanding the basic concepts of genetics, helping students to develop their analytical, quantitative and problem solving skills from classical to molecular genetics.

Theory

UNIT I

Beginning of genetics; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.

UNIT II

Multiple alleles. Multiple Factor hypothesis.Gene interactions.Lethal genes, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; intergenic and intragenic complementation and recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

UNIT III

Population - Mendelian population – Random mating population -Frequencies of genes and genotypes-Causes of change: Hardy-Weinberg equilibrium.

UNIT IV

Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis. Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code,regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes,t-RNAs and translational factors.

UNIT V

Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.

UNIT VI

Mutation induction and detection, Molecular mechanisms of mutation, repair and suppression

UNIT VII

Regulation of gene activity in prokaryotes and eukaryotes; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing.

UNIT VIII

Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.Human genetics and Gene therapy.Intrduction to recombinant DNA technology-restriction enzymes,vectors,genetic transformation and genomics.

Practical

Numerical exercises related to mendalian principles and gene interactions.Multiple alleles ABO blood group system.Analysis of penetrance and expressivity(PTC test). Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests;

Suggested Readings

Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley &Sons.

Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu.Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ.
Russell PJ. 1998. *Genetics*. The Benzamin/Cummings Publ. Co.
Snustad DP & Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley & Sons.
Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India
Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs.
Uppal S, Yadav R, Subhadra & Saharan RP. 2005. *Practical Manual onBasic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

2.**GP 502 CELL BIOLOGY AND CYTOGENETICS 2+1**

Objective

To provide insight into structure and functions of Cell, chromosomes,chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

Theory

UNIT I

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastidschloro/chromoplast, mitochondria endoplasmic reticulum, Golgi complex,lysosomes, peroxisomes.

UNIT II

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition; Cell division and physiology of cell division.

UNIT I

Architecture of chromosome in prokaryotes and eukaryotes;Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; Artificial chromosome construction and its uses; Special types of chromosomes.

UNIT II

Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over-mechanisms and theories of crossing over- recombination models, cytological basis, - Variation in chromosome structure: Evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding and painting

UNIT III

Structural and Numerical variations of chromosomes and their implications- Symbols and terminologies for chromosome numbers - euploidy -haploids, diploids and polyploids ; Utilization of aneuploids in gene location - Variation in chromosome behaviour - somatic segregation and chimeras – endomitosis and somatic reduction ; Evolutionary significance of chromosomal aberrations - balanced lethals and chromosome complexes.

UNIT IV

Inter-varietal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids –- Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer – Alien addition and substitution lines – creation and utilization;

UNIT V

Reversion of autopolyploids to diploids; Genome mapping in polyploids -Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica)

– Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids – Bridge species.

UNIT VI

Fertilization barriers in crop plants at pre-and postfertilization levels- ;Chromosome manipulations in wide hybridization ; case studies –Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes, - Observing sections of specimen using Electron microscope; Preparing specimen for observation – Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on the course of mitosis in wheat, pearl millet - Studies on thecourse of mitosis in onion and *Aloe vera* - Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops - Using micrometers and studying the pollen grain size in various crops - Various methods of staining and preparation of temporary and permanent slides - Pollen germination *in vivo* and *in vitro;* Microtomy and steps in microtomy; Agents employed for the induction of various ploidy levels; Solution preparation and application at seed, seedling level.Identification of polyploids in different crops - Induction and identification of haploids; Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly – Morphological observations on alloployploids - Morphological observations on aneuploids - Cytogenetic analysis of interspecific and intergeneric crosses -Maintenance of Cytogenetic stocks and their importance in crop breeding - Various ploidy levels due to somaclonal variation ; Polyploidy in ornamental crops.

Suggested Readings

Becker K & Hardin. 2004. *The World of Cell*. 5th Ed. Pearson Edu.

Carroll M. 1989. *Organelles*. The Guilford Press.

Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall.

Darlington CD & La Cour LF. 1969. *The Handling of Chromosomes*.Georger Allen & Unwin Ltd.

Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRL Press.

Gray P. 1954. *The Mirotomist's Formulatory Guide*. The Blakiston Co.

Gupta PK & Tsuchiya T. 1991. *Chromosome Engineering in Plants:Genetics, Breeding and Evolution*. Part A. Elsevier.

Gupta PK. 2000. *Cytogenetics*. Rastogi Publ.

Johannson DA. 1975. *Plant Microtechnique*. McGraw Hill.

Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*.John Wiley & Sons.

Khush GS. 1973. *Cytogenetics of Aneuploids*. Academic Press.

Sharma AK & Sharma A. 1988. *Chromosome Techniques: Theory andPractice*. Butterworth.

Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ.Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

3.GP 503 PRINCIPLES OF PLANT BREEDING 2+1

Objective

To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Theory

UNIT I

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants - Centres of Origin-biodiversity and its significance.

UNIT II

Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding.

UNIT III

Self-incompatibility and male sterility in crop plants and their commercial exploitation.

UNIT III

Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach).

UNIT IV

Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

UNIT V

Breeding methods in asexually/clonally propagated crops, clonal selection apomixis-evolutionary and genetic problems in crops with apomixis, clonal selection.

UNIT VI

Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding.

UNIT VII

Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses.

UNIT VIII

Cultivar development - testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops.

Suggested Readings

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH.
Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.
Gupta SK. 2005. *Practical Plant Breeding*. Agribios.
Pohlman JM & Bothakur DN. 1972. *Breeding Asian Field Crops*. Oxford & IBH.
Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*.Narosa Publ. House.
Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society.
Singh BD. 2006. *Plant Breeding*. Kalyani.
Singh P. 2002. *Objective Genetics and Plant Breeding*. Kalyani.
Singh P. 2006. *Essentials of Plant Breeding*. Kalyani.
Singh S & Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

4.GP 504 PRINCIPLES OF QUANTITATIVE GENETICS 2+1

Objective

To impart theoretical knowledge and computation skills regarding component of variation and variances, scales, mating designs and gene effects.

Theory

UNIT I

Mendelian traits *vs* polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects.

UNIT II

Principles of Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance.

UNIT III

Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

UNIT IV

Generation mean analysis; Mating designs- Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis – principles and interpretation.

UNIT V

QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II – Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation – Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model – Principal Component Analysis model - Additive and multiplicative model – Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

Suggested Readings

Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

Falconer DS & Mackay J. 1998. *Introduction to Quantitative Genetics*. Longman.

Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall.

Mather K & Jinks JL. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.

Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.

Naryanan SS & Singh P. 2007. *Biometrical Techniques in Plant Breeding. Kalyani.*

Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.

Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.

Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.

Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

5.GP 505 MUTAGENESIS AND MUTATION BREEDING 2+1

Objective

To impart the knowledge about general principles of radiation and various tests/methods for detection of radiation effects on the living cells, genetic risks involved and perspectives of advances made.

Theory

UNIT I

Mutation and its history - Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations - Detection of mutations in lower and higher organisms – paramutations.

UNIT II

Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations *viz*., X rays, γ rays, alpha and β particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects –RBE and LET relationships.

UNIT III

Effect of mutations on DNA - Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects - Dosimetry - Objects and methods of treatment - Factors influencing mutation: dose rate, acute *vs* chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects - Radiation sensitivity andmodifying factors: External and internal sources- Oxygen, water content, temperature and nuclear volume.

UNIT IV

Chemical mutagens- Classification - Base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action - Dose determination and factors influencing chemical mutagenesis - Treatment methods using physical and chemical mutagens – Combination treatments; Other causes of mutation - direct and indirect action, comparative evaluation of physical and chemical mutagens.

UNIT V

Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras *etc*., - Observing mutagen effects in M2 generation - Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations -– Mutations in traits with continuous variation.

UNIT VI

Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage *etc*. - Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation - Comparative evaluation of physical and chemical mutagens for creation of variability in the same species – Case studies.

UNIT VII

Use of mutagens in creating oligogenic and polygenic variations – Case studies - *In vitro* mutagenesis – callus and pollen irradiation; Handling of segregating genrations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement,etc) in different crops- Procedures for micromutations breeding/polygenic mutations- Achievements of mutation breeding- varieties released across the world- Problems associated with mutation breeding.

UNIT VIII

Use of mutagens in genomics, allele mining, TILLING.

Practical

Learning the precautions on handling of mutagens; Dosimetry - Studies of different mutagenic agents: Physical mutagens - Studies of different mutagenic agents: Chemical mutagens - Learning on Radioactivity – Production of source and isotopes at BRIT, Trombay - Learning about gamma chamber; Radiation hazards - Monitoring – safety regulations and safe transportation of radioisotopes - Visit to radio isotope laboratory ; learning on safe disposal of radioisotopes - Hazards due to chemical mutagens - Treating the plant propagules at different doses of physical and chemical mutagens - Learning combined mutagenic treatments; Raising the crop for observation - Mutagenic effectiveness and efficiency; Calculating the same from earlier literature - Study of M1 generation – Parameters to be observed; Study of M2 generation – Parameters to be observed; Mutation breeding in cereals and pulses – Achievements made and an

analysis - Mutation breeding in oilseeds and cotton – Achievements and opportunities - Mutation breeding in forage crops and vegetatively propagated crops; Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

Suggested Readings

Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London. Chadwick KH & Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer-Verlag.
Cotton RGH, Edkin E & Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.
International Atomic Energey Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energey Agency, Vienna, Italy.
Singh BD. 2003. *Genetics*. Kalyani.
Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

6. GP 506 POPULATION GENETICS 1+1

Objective

To impart knowledge on structure, properties and their breeding values of different population.

Theory

UNIT I

Population - Properties of population - Mendelian population – Genetic constitution of a population through time, space, age structure etc. Mating systems - Random mating population - Frequencies of genes and genotypes-Causes of change: population size, differences in fertility and viability, migration and mutation.

UNIT II

Hardy-Weinberg equilibrium - Hardy-Weinberg law - Proof – Applications of the Hardy-Weinberg law - Test of Hardy-Weinberg equilibrium – Mating frequencies - Non-dominance - Codominance - Snyder's ratio, importance and its effect over random mating in succeeding generations.

UNIT III

Multiple alleles - More than one locus - Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency - Migration – Mutation - Recurrent and nonrecurrent - Selection - Balance between selection and mutation – Selection favouring heterozygotes - Overdominance for fitness.

UNIT IV

Non random mating: selfing –inbreeding coefficient –effects of inbreeding,degrees of inbreeding depression,linkage disequilibrium,epistasis, panmictic index – sibmating - Assortative mating and disassortative mating – Pedigree populations and close inbreeding - Estimation of selection - Estimation of disequilibrium - Estimation of linkage - Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops.

UNIT V

Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- Adapative organization of gene pools, Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage-Survival of recessive and deleterious alleles in populations.Homozygous and heterozygous balance GXE interaction and joint scaling test and genetic divergence.

Practical

Genetic exercise on probability**;** Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average affect of gene substitution and

breeding value; Exercises on inbreeding and linkage disequilibrium- Cavalli's joint scaling test; Exercises of different mating designs; Estimation of different population parameters from experimental data; Measurement of genotype-environment interaction; Genetic divergence.

Suggested Readings

Chawla V & Yadava RK. 2006. *Principles of Population Genetics - APractical Manual*. Dept. of Genetics, CCS HAU Hisar.

Falconer DS & Mackay J.1996. *Introduction to Quantitative Genetics*. Longman.

Jain JP, Jain J & Parbhakaran, VT. 1992. *Genetics of Populations*. South Asia Books.

Li CC. 1955. *Population Genetics*. The Univ. of Chicago Press.

Mather K & Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.

Sorrens D & Doniel G. 2007. *Methods in Quantitative Genetics*. Series: *Statistics for Biology and Health*. Likelihood.

Tomar SS. 1992. *Text Book of Population Genetics*. Universal Publication.

7. GP 507 HETEROSIS BREEDING 1+1

Objective

To provide understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

Theory

UNIT I

Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops crops.

UNIT II

Pre Mendelian and Post-Mendelian ideas - Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; - Evolutionary concepts of heterosis.

UNIT III

Prediction of heterosis from various crosses- Inbreeding depression, frequency of inbreeding and residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies. - Relationship between genetic distance and expression of heterosis – case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis, Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis.

UNIT IV

Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of selfincompatibility in development of hybrids; Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids.

UNIT V

Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid.

UNIT VI

Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis.

UNIT VII

Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

Practical

Selection indices and selection differential – Calculations and interpretations - Male sterile line characterization in millets; Using morphological descriptors; Restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters -Hybrid seed production in field crops – an account on the released hybrids; their potential; Problems and ways of overcoming it; hybrid breeding at National and International level; Opportunities ahead.

Suggested Readings

Proceedings of *Genetics and Exploitation of Heterosis in Crops* – An International Symposium CIMMYT, 1998.

Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.

Ben Hiu Lin. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.

De Joung G. 1988. *Population Genetics and Evolution*. Springer-Verlag.

Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.

Mettler LE & Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall.

Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Srivastava S & Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.

8.GP 508 MOLECULAR GENETICS 2+1

Objective

To impart knowledge in theory and practice about DNA, molecules like proteins and nucleic acids.

Theory

UNIT I

Historical background of molecular genetics; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance;

UNIT II

Transposable elements; Mechanisms of recombination in prokaryote,DNA-repair,RNA-

UNIT III

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCRbased cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification,Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

UNIT IV

Genomics and proteomics; Functional and pharmacogenomics;Metagenomics.

proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging

UNIT V

Methods of studying polymorphism at biochemical and DNA level; Gene silencing; genetics of mitochondria and chloroplasts.

UNIT VI

Techniques of DNA isolation, quantification and analysis; Genotyping;Sequencing techniques; Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.),mapping populations (F2s, back crosses, RILs, NILs and DH).

UNIT VII

Molecular mapping and tagging of agronomically important traits.Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.genome mapping in polyploids.

UNIT VIII

Bioinformatics & Bioinformatics tools

Practical

Morphological and Gram staining of natural bacteria; Study of lytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell;Quantitative estimation of DNA, RNA and protein in an organism;Fluorescent *in situ* hybridization (FISH)- Genome *in situ* hybridization GISH.DNA extraction and PCR amplification -Electrophoresis – basic principles and running of amplified DNA -Extraction of proteins and isozymes – DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship,construction of genetic linkage maps using computer software.

Suggested Readings

Bruce A.2004. *Essential Cell Biology*. Garland.
Karp G.2004. *Cell and Molecular Biology: Concepts and Experiments*.
John Wiley.
Klug WS & Cummings MR 2003. *Concepts of Genetics*. Scot, Foreman &Co.
Lewin B. 2008. *IX Genes*. John Wiley & Sons
Lodish H, Berk A & Zipursky SL. 2004. *Molecular Cell Biology*. 5th Ed.
WH Freeman.
Nelson DL & Cox MM. 2005. *Lehninger's Principles of Biochemistry*.
WH Freeman & Co.
Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.
Schleif R.1986. *Genetics and Molecular Biology*. Addison-Wesley Publ.Co.

9.GP 509 BIOTECHNOLOGY FOR CROP IMPROVEMENT 2+1

Objective

To impart knowledge and practical skills to use biotechnological tools in crop improvement.

Theory

UNIT I

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding.

UNIT II

Tissue culture- History, callus, suspension cultures,organ culture, cloning; Regeneration;Somatic embryogenesis in vitro techniques to overcome the fertilization

barriers in crops Anther culture; somatic hybridization techniques;Meristem, ovary and embryo culture; cryopreservation. Secondary metabolite production

UNIT III

Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression,Generation of EDVs.

UNIT IV

Recombinant DNA technology, transgenes, method of transformation,selectable markers and clean transformation techniques, Vectors, vector preparation and cloning, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds,sugarcane etc. Commercial releases. Transgenic bacteria and bioethics

UNIT V

Biotechnology applications in male sterility/hybrid breeding, molecular farming.

UNIT VI

MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights

UNIT VIII

Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media –interpretations - Inoculation of explants;anther culture and ovule culture. Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit.Transformation using *Agrobacterium* strains, GUS assay in transformed cells / tissues. use of A*grobacterium* mediatedmethod and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse andlearning the practical considerations.

Suggested Readings

Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology:Concepts, Methods and Applications*. Oxford & IBH.

Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.

Hackett PB, Fuchs JA & Messing JW. 1988. *An Introduction toRecombinant DNA Technology - Basic Experiments in Gene Manipulation.* 2nd Ed. Benjamin Publ. Co.

Sambrook J & Russel D. 2001. *Molecular Cloning* - a Laboratory Manual.3rd Ed. Cold Spring Harbor Lab. Press.

Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani.

10.GP 510 BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE 2+1

Objective

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress resistant varieties.

Theory

UNIT I

Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops - Concepts in insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR);Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defense mechanisms against viruses and bacteria.

UNIT II

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants. Quantitative resistance/Adult plant resistance and Slow rusting resistance - Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies.

UNIT III

Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

UNIT IV

Classification of abiotic stresses - Stress inducing factors –moisture stress/drought and water logging & submergence; Acidity, salinity/alkalinity/sodicity; High/low temperature, wind, etc. Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies. Pollution,heavy metal toxicity, Green house gases and its impact on crops

UNIT V

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton etc; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.

UNIT VI

Exploitation of wild relatives as a source of resistance to biotic and abiotic factors in major field crops - Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitnases and Bt for diseases and insect pest management- Achievements.

Practical

Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level - Phenotypic screening techniques for nematodes and borers; Ways of combating them; Breeding strategies - Weeds – ecological, environmental impacts on the crops; Breeding for herbicide resistance - Evaluating the available populations like RIL, NIL etc. for pest resistance; Use of standard MAS procedures - Phenotypic screening methods for diseases caused by fungi and bacteria;Symptoms and data recording; use of MAS procedures - Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation - Screening crops for drought and flood resistance; factors to be considered and breeding strategies - Screening varieties of major crops for acidity and alkalinity-their effects and breeding strategies; Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them.

Suggested Readings

Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.
Christiansen MN & Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International.
Fritz RS & Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.
Li PH & Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York
Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA, ARS, Washington DC.
Maxwell FG & Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons.
Painter RH. 1951. *Insect Resistance in Crop Plants*. MacMillan, New York.
Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths.
Sakai A & Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.
Turener NC & Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons. van der Plank JE. 1982. *Host-Pathogen Interactions in Plant Disease*. Academic Press.

11.GP 511 BREEDING CEREALS, FORAGES AND SUGARCANE 2+1

Objective

To provide insight into recent advances in improvement of cereals and forage crops and sugarcane using conventional and modern biotechnological approaches.

Theory

UNIT I

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.* – Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding.New plant type concept.Genetic Engineering.

UNIT II

Wheat: Evolution and distribution of species and forms - wild relatives and germplasm; cytogenetics and genome relationship; Breeding objectivesyield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis etc; Sorghum: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc; Pearl millet: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc.

UNIT III

Maize: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectivesyield, quality characters, biotic and abiotic stress resistance etc.

UNIT IV

Sugarcane: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc - Forage grasses: Evolution and

distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance etc., synthetics, composites and apomixes.

UNIT V

Forage legumes: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc - Tree fodders: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc*, palatability studies.

UNIT VI

Distinguishing features of popular released varieties in Rice and Sorghum - Wheat, Pearl millet, Maize and other millets - Sugarcane, forage grasses and legumes and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.

Practical

Floral biology – emasculation - pollination techniques ; Study of range of variation for yield and yield components – Study of segregating populations and their evaluation - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; Use of softwares for database management and retrieval.

Suggested Readings

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.

Chandraratna MF. 1964. *Genetics and Breeding of Rice*. Longmans.

Chopra VL & Prakash S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH.

Gill KS. 1991. *Pearl Millet and its Improvement*. ICAR.

IRRI. 1964. *Rice Genetics and Cytogenetics*. Elsevier.

IRRI. 1986. *Rice Genetics*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

IRRI. 1991. *Rice Genetics II*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

IRRI. 1996. *Rice Genetics III*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

IRRI. 2000. *Rice Genetics IV*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

Jennings PR, Coffman WR & Kauffman HE. 1979. *Rice Improvement*.
IRRI, Los Banos, Manila, Philippines.

Kannaiyan S, Uthamasamy S, Theodore RK & Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*.
Directorate of Extension Education, TNAU, Coimbatore.

Murty DS, Tabo R & Ajayi O. 1994. *Sorghum Hybrid Seed Production and Management*. ICRISAT, Patancheru, India.

Nanda JS. 1997. *Manual on Rice Breeding*. Kalyani.

Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.

Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994.
Crop Breeding in India. International Book Distributing Co.

Slafer GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.

Walden DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.

12. GP 512 BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS 2+1

Objective

To provide insight into recent advances in improvement of legumes, oilseeds and fibre crops using conventional and modern biotechnological approaches.

Theory

UNIT I

Pigeonpea: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship; Morphological and molecular descriptors used for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc* - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes.

UNIT II

Chickpea: Evolution and distribution of species and forms - Wild relatives and germplasm - cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Protein quality improvement; Conventional and modern plant breeding approaches, progress made - Breeding for anti nutritional factors.

UNIT III

Other pulses: Greengram, blackgram, fieldpea, lentil,, lathyrus, cowpea, lablab, mothbean: Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

UNIT IV

Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress etc.

UNIT V

Rapeseed and Mustard: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc; Oil quality – characteristics in different oils; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT VI

Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT VII

Other oilseed crops: Sunflower, sesame, safflower, niger: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements.

UNIT VIII

Castor: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, breeding objectivesyield, quality characters, biotic and abiotic stress *etc* - Hybrid breeding in castor – opportunities, constraints and achievements.

UNIT IX

Cotton: Evolution of cotton; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc; Mesta and minor fibre crops: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc.

UNIT X

Distinguishing features of the released varieties in pulses, oilseeds and cotton; Maintenance of seed purity and seed production.

Practical

Use of descriptors for cataloguing – Floral biology - emasculation – pollination techniques; Study of range of variation for yield and yield components - Study of segregating populations in Redgram, Greengram, Blackgram and other pulse crops; Attempting crosses between blackgram and greengram. Use of descriptors for cataloguing – Floral biology, emasculation, pollination techniques of oilseed crops like Sesame, Groundnut, Sunflower and Castor, Cotton: Use of descriptors for cataloguing – Floral biology - Learning on the crosses between different species - Cotton: Study of range of variation for yield and yield components - Study of segregating populations - evaluation - Trait based screening for stress resistance - Cotton fibre quality evaluation –conventional and modern approaches; analysing the lint samples of different species, interspecific and interracial derivatives for fibre quality and interpretation – Development and maintenance of male sterile lines Evaluation of cotton cultures of different species for insect and disease resistance – Learning the mechanisms of resistance, quantifying the resistance using various parameters; Evaluating the germplasm of cotton for yield, quality and resistance parameters – learning the procedures on development of Bt cotton - Visit to Cotton Technology Laboratory and Spinning Mills – Learning on cotton yarn production, its quality evaluation and uses.

Suggested Readings

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.

Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.

Chopra VL. 1997. *Plant Breeding*. Oxford & IBH.

Nath V & Lal C. 1995. *Oilseeds in India*. Westvill Publ. House.

Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.

Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.

Singh DP. 1991. *Genetics and Breeding of Pulse Crops*. Kalyani.

Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. *Crop Breeding in India*. International Book Distributing Co.

Smartt J. 1994. *The Groundnut Crop - a Scientific Basis for Improvement*. Chapman & Hall.

13. GP 513 BREEDING FOR QUALITY TRAITS 1+1

Objective

To provide insight into recent advances in improvement of quality traits in rice, millets, legumes, oilseeds and forage crops and for physiological efficiency using conventional and modern biotechnological approaches.

Theory

UNIT I

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective - Breeding for grain quality parameters in rice and its analysis - Golden rice and aromatic rice – Breeding strategies, achievements and application in Indian context - Molecular basis of quality traits and their manipulation in rice - Post harvest manipulation for quality improvement.

UNIT II

Breeding for baking qualities in wheat; Characters to be considered and breeding strategies - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats.

UNIT III

Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize – Concept and breeding strategies – Breeding for quality improvement in forage crops - Genetic resource management for sustaining nutritive quality in crops.

UNIT IV

Breeding for quality in pulses - Breeding for quality in groundnut, sesame, sunflower and minor oilseeds – Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton.

UNIT V

Breeding for quality in major fruits and vegetable crops.

UNIT V1

Breeding for quality in perennial crops and spices.

UNIT V11

Breeding for quality in tropical tuber crops.

UNIT V111

Breeding for quality in important ornamental and medicinal plants

UNIT 1X

Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; Classification and importance – Nutritional genomics and Second generation transgenics.

Practical

Grain quality evaluation in rice; Correlating ageing and quality improvement in rice - Quality analysis in millets; Estimation of antinutritional factors like tannins in different varieties/hybrids; A comparison - Quality parameters evaluation in wheat; Quality parameters evaluation in pulses - Quality parameters evaluation in oilseeds fruits,perennial crops,spices,tropical tuber crops,ornamental and medicinal plants; Value addition in crop plants ; Post harvest processing of major field crops; Quality improvement in crops through tissue culture techniques; Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

Suggested Readings

Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.

Chopra VL. 1997. *Plant Breeding*. Oxford & IBH.

FAO 2001. *Speciality Rices of the World - Breeding, Production andMarketing*. Oxford & IBH.
Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.
Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
Singh BD. 1997. *Plant Breeding*. Kalyani.
Singh RK, Singh UK & Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

14.GP 514 GENE REGULATION AND EXPRESSION 2+0

Objective

To provide insight into recent advances in the phenomenon of gene regulation and mechanisms by which plants and microbes express different traits and how these are modified during different stages.

Theory

UNIT I

Introduction: Gene regulation-purpose; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.

UNIT II

Coordinated genetic regulation-examples- Anthocyanin and gene families and maize; Genetic and molecular basis depending on tissue specificity.

UNIT III

Gene expression-Transposons in plant gene expression, cloning-transposon tagging; Light regulated gene expression-model systems in *Arabidopsis* and maize; Paramutations and imprinting of genes and genomes.

UNIT IV

Transgene expression and gene silencing mechanisms; Regulatory genes horizontal and vertical homology; Transformation-regulatory genes as visible markers; Reporter systems to study gene expression; Combinatorial gene control.

UNIT V

Eukaryotic transcriptional control; Translational and post-translational regulation; Signal transduction; Stress-induced gene expression; Gene traps and enhancer traps.

Suggested Readings

Lewin B. 2008. *Genes IX*. John Wiley & Sons.
Schleif R.1986. *Genetics and Molecular Biology*. Addison-Wesley.
Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.
Brown TA. 2002. *Genomes.* Bios Scientific Publ.
Tamarin RH. 1999. *Principles of Genetics*. Wm C Brown Publ.
Griffiths AJF. 2000. *An Introduction to Genetic Analysis*. WH Freeman.
Hexter W & Yost HT. 1976. *The Science of Genetics*. Prentice Hall.
Singer M & Berg P.1991. *Genes and Genomes*. John Wiley & Sons.
Hartl DL & Jones EW. 1998. *Genetics Principles and Analysis*. Jones &Barlett Publ.
Micklos DA & Freyer G. 2003. *DNA Science - A First Course*. CPLScientific Publ.
Brooker RJ. 2004. *Genetics Analysis and Principles*. Addison-WesleyLongman.
Watson JD. 2004. *Molecular Biology of the Gene*. Pearson Edu.

15.GP 515 MAINTENANCE BREEDING AND CONCEPTS OF VARIETY RELEASE AND SEED PRODUCTION 1+1

Objective

To apprise the students about the variety deterioration and steps to maintain the purity of varieties & hybrids and principles of seed production in self & cross pollinated crops.

Theory

UNIT I

Variety Development and Maintenance; Definition- variety, cultivar,extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid,and population; Variety testing, release and notification systems in India and abroad.

UNIT II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding.

UNIT III

Factors responsible for genetic deterioration of varieties - safeguards during seed production; Maintenance of varieties in self and cross-pollination crops- isolation distance; Principles of seed production; Methods of nucleus and breeder seed production.

UNIT IV

Generation system of seed multiplication -nucleus, breeders, foundation, certified, - Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton, jute) and forages (guar, forage sorghum, teosinte, oats, berseem,lucerne).; Seed certification procedures; Seed laws and plant variety protection regulations in India and international systems.

Practical

Identification of suitable areas/locations for seed production; Ear-to-row method and nucleus seed production - Main characteristics of released and notified varieties, hybrids and parental lines; Identification of important weeds/objectionable weeds; Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops; Hybrid seed production technology of important crops.

Suggested Readings

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*.

Department of Plant Breeding. CCS HAU Hisar.

Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.

McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

Musil AF. 1967. *Identification of Crop and Weed Seeds*. Handbook No. 219, USDA, Washington, DC.

Poehlman JM & Borthakur D. 1969. *Breeding Asian Field Crops*. Oxford& IBH.

Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani.

Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.

Tunwar NS & Singh SV. 1985. *Handbook of Cultivars*. ICAR.

16. GP 516 GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE 2+1

Objective

To provide information about collection, germplasm exchange, quarantine, maintenance and use of plant genetic resources including genetically modified plants.

Theory

UNIT I

Germplasm,gene bank,requisites for a gene bank,gene erosion,constraints of gene bank.History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora-germplasm procurement from different agencies.

UNIT II

Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection;Coarse and fine grid surveys; Practical problems in plant exploration; Use of *in vitro* methods in germplasm collection.

UNIT III

Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens.

UNIT IV

Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT V

History, principles, objectives and importance of plant introduction; Prerequisites,conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses,phytoplasma etc.).

UNIT VI

Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

UNIT VII

Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

Practical

Plant exploration and collection; Techniques of coarse and fine grid surveys; Identification of wild relatives of crop plants- Example of collection, cataloguing and preservation of specimens; Sampling techniques of plant materials; Visiting ports, airports to study the quarantine regulations; Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging; Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques(controlled green houses/growth chambers, etc); Detection of GMOs and GEPs; Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

Suggested Readings

Briggs D. 1997. *Plant Variation and Evolution*. Science Publ.

Cronquist AJ. 1981. *An Integrated System of Classification of Flowering Plants*. Columbia Univ. Press.

Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. *Germplasm Conservation A Compendium ofAchievements*. NBPGR, New Delhi.

di Castri F & Younes T. 1996. *Biodiversity Science and Development: Towards New Partnership*. CABI & International Union for Biol.Sci. France.

Gurcharan Singh. 2004. *Plant Systematics: An Integrated Approach*.Science Publ.

Lawrence GMH. (Ed.). 1951. *Taxonomy of Vascular Plants*. London.

Paroda RS & Arora RK. 1991. *Plant Genetic Resources Conservation and Management Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.

Pearson LC. 1995. *The Diversity and Evolution of Plants*. CRC Press.

Singh BP. 1993. *Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management.* Indo-US PGR ProjectManagement.

Sivarajan VV. 1991. *Introduction of Principles of Plant Taxonomy*. SciencePubl.

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Takhrajan A. 1997. *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.

Wiersema JH. 1999. *World Economic Plants: A Standard Reference*.Blanca Leon.

17. GP 517 DATA BASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR 2+1

Objective

To train the students in germplasm data base management using modern tools and softwares.

Theory

UNIT I

Statistical techniques in management of germplasm; Core identification, estimation of sample size during plant explorations, impact of sampling on population structure, sequential sampling for viability estimation; Introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and numograms; Estimation of sample size for storage and viability testing.

UNIT II

Germplasm documentation; Basics of computer and operating systems; Database management system, use of statistical softwares, pictorial and graphical representation of data; introduction to communication network.

UNIT III

Germplasm management system- global scenario; Genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; Predictive methods for identification of useful germplasm; Characterization of germplasm and evaluation procedures including specific traits; Gene markers and their use in PGR management.

UNIT IV

Management and utilization of germplasm collections; Concept of core collection, molecular markers and their use in characterization; Evaluation and utilization of genetic resources; Pre-breeding/ genetic enhancement, utilizing wild species for crop improvement; Harmonizing agrobiodiversity and agricultural development crop diversificationparticipatory plant breeding.

Practical

Basics of computer and operating systems; Identification of useful germplasm, evaluation of crop germplasm; Statistical techniques in management of germplasm-estimation of sample size for storage and viability testing; Evaluation procedure and experimental protocols (designs and their analysis), Assessment of genetic diversity; Techniques of

Characterization of germplasm; Molecular markers and their use in characterization.

Suggested Readings

Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book for Genetic Resources Documentation*. IPGRI, Rome, Italy.

Puzone L & Th. Hazekamp 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, NewDelhi.

Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.

18.518 BREEDING OF TROPICAL CROPS 1+1

Objective

To provide insight into recent advances in improvement of cereals and pulses,oil yielding crops,tuber crops.perennial crops,vegetables,medicinal and aromatic and ornamentals using conventional and modern biotechnological approaches.

Theory

UNIT I

Perennial commercial crops Coconut, Arecanut, rubber, cashew cardamom, black pepper. Evolution and distribution of species and forms. Cytogenetics, breeding objectives – field and quality: conventional and modern breeding approaches, achievements hybrid varieties.

Unit II

Tropical tuber crops – Tapioca, Sweet potato, yam, colocasia: Evolution distribution of forms and species, classification, cytogenetics, breeding objectives yield and quality, breeding methods, achievements.

Unit III

Medicinal and aromatic plants- Distribution of forms and species – cytogenetics, breeding objectives, breeding methods and achievements.Medicinal plants: Lemongrass eucalyptus *Oscimum*, *Piper longum*, *Kaempferia*, *Sida* spp. and other important tree medicinal plants. Ornamental plants Orchid, *Anthurium*- origin, distribution of species and forms, cytogenetics breeding objectives yield and quality, breeding methods, achievement.

UNIT 1V

Vegtables, evolution and distribution of species and forms – wild relatives and germplasm, Cytogenetics and genome relationship – Breeding objects – yield, quality characters, biotic and abiotic stress resistance etc. in important vegetable crops.

UNIT V

Fruit – Crops : Mango and Banana origin, distribution of species and forms, cytogenetics, breeding objectives, yield and quality, breeding methods, achievement

Practical

Floral biology – emasculation - pollination techniques ; Study of range of variation for yield and yield components – Study of segregating populations and their evaluation - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; Use of softwares for database management and retrieval.Practical learning on the cultivation of fruit crops, vegetables, medicinal plants, perennials like coconut,arecanut,rubber,cashew,cardamom,black pepper,tuber crops,medicinal and aromatic plants,orchids,anthurium and vegetables.

Suggested Readings

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.

Kannaiyan S, Uthamasamy S, Theodore RK & Palaniswamy S. 2002. *NewDimensions and Approaches for Sustainable Agriculture*.Directorate of Extension Education, TNAU, Coimbatore.

Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.

Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994.*Crop Breeding in India*. International Book Distributing Co.

Slafer GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker. Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.

Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. Nath V & Lal C. 1995. *Oilseeds in India*. Westvill Publ. House.

Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.

Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.

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Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. *Crop Breeding in India*. International Book Distributing Co.

Basset. M.J.(Ed.) 1986. Breeding vegetable Crops A VI publications

Feria. M.S, Arya. P.S. and Choudhary a.k. 2000Vegetable Crops Breeding and Seed Production Vol, I Kalyani.

Kalloo. G. 1988. Vegetable Breeding Vols. I – III – CRC Press

Kalloo.G.1998. Vegetable Breeding Vols. I – III (Combined Ed.) Panima Edn. Book Agency.

Kumar I.C. and Dhaliwal. M.S. 1990. Technics of Developing Hybrids in Vegetable Crops. Agro Botanical Publications.
Singh P.K./, Dasgupta S.K. and Tripathi.S.K. 2004. Hybrid Vegetable Development International Book Distributing Co.

19.GP519 Intellectual property rights and plant breeding 2+0

Theory

Unit I

Property rights – (IPR) issues involved – Nature of IPR.

Unit II

Patents – Conditions for patents – Historical aspects of patents - Patents in India – case studies. Indian Patent Act – Facilitating patents – Intellectual Property Management Division (IPMD) under CSIR.

UNIT III

Copy rights – History of copy right protection – Fair Dealing - copy right protection in India. Trade marks – purpose, importance, systems, trade mark protection.

UNIT IV

Geographical indications (GI) – benefits – protection of GI – national & international level – goods that can be protected under GI – procedure, violation of GI protection – examples.

UNIT V

IPR on plant varieties – Plant Breeders' Rights - history – PPV & FR Act, 2001 – Registration of varieties under the Act- Novelty, Distintiveness, unifiormity and stability – Extant variety, Farmers' variety. Farmers' rights – researchers' rights.

UNIT VI

IPR on biological diversity – Convention on Biological Diversity (CBD), Regulation of biodiversity – National Biodiversity Authority (NBA), State Biodiversity Board (SBB). ICAR guidelines for IPR management. Biodiversity Act.

UNIT VII

Seed Bill – its impact. Various treaties – their comparisons. IPR and participatory technology – Participatory Plant Breeding.

Suggested readings

Chahal, G. S and Gosal, S. S. 2002. *Principles and Procedures of Plant Breeding.* Narosa Publishing House, New Delhi

Elsy, C.R., Jesy Thomas, K. and Mohandas, M. 2006. Primer on IPR in Agriculture. Kerala Agricultural University, Thrissur. p.36

Maskus, K.E. (2000), *Intellectual Property Rights in the Global Economy*, Washington,D.C.: Institute for International Economics.

20 GP 520 Genetics 2 + 0

Objectives

Offered for Agricultural Statistics students only

Theory

UNIT I

Physical basis of heredity–cell structures and functions-Cell divisions– mitosis, meiosis and their significance

UNIT II

Mendelian inheritance-application of statistical techniques in substantiating Mendelian principles and modifications to Mendelian ratios like dominance, incomplete dominance, Epitasis.

UNIT III

Application of statistics in detecting linkage, crossing over, chromosome mapping etc.

UNIT IV

Quantitative traits-Multiple Factor Hypothesis-lethal genes

UNIT V

Sex determination and sex linked characters and their identification through statistical techniques.

UNIT VI

Genetics of population-gene and genotype frequency – Hardy-Weinberg's law, its derivation- forces changing gene frequency.

References

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Genetics.2004.Verma P S and Aggarwal V K

Ph. D COURSES

1.GP 601 PLANT GENETIC RESOURCES AND PRE-BREEDING 2+0

Objective

To provide information about collection, evaluation, documentation, maintenance and use of plant genetic resources for crop improvement.

Theory

UNIT I

Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and global pattern of diversity; Basic genetic resources and transgenes.

UNIT II

Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation.

UNIT III

Germplasm conservation- *in situ, ex situ*, and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; Registration of plant genetic resources.

UNIT IV

PGR data base management; Multivariate and clustering analysis, descriptors; National and international protocols for PGR management; PGR for food and agriculture (PGRFA); PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges; Seed Act, *sui generis* system; Geographical indicators, Intellectual property; Patents, copyrights, trademarks and trade secrets.

UNIT V

Journey from wild to domestication; Genetic enhancement- need for genetic enhancement; Genetic enhancement in pre Mendelian era and 21st century; Genetic enhancement and plant breeding; Reasons for failure in genetic enhancement; Sources of genes/ traits- novel genes for quality.

UNIT VI

Distant Hybridization: Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer tools and techniques into cultivated species; Validation of transferred genes and their expression.

UNIT VII

Post-genomic tools for genetic enhancement of germplasm; Prebreeding through chromosome manipulation; Application of biotechnology for Genetic enhancement-Achievements.

UNIT VIII

Utilization of genetic resources, concept of core and mini-core collections, genetic enchancement/Prebreeding for crop improvement including hybrid development.

Suggested Readings

Frankel OH & Bennett E. 1970. *Genetic Resources in Plants – their Exploration and Conservation*. Blackwell.

Gautam PL, Dass BS, Srivastava U & Duhoon SS. 1998. *Plant Germplasm ollecting: Principles and Procedures*. NBPGR, New Delhi.

Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book for Genetic Resources Documentation*. IPGRI, Rome, Italy.
Paroda RS & Arora RK. 1991. *Plant Genetic Resources, Conservation and Management. Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.
Puzone L & Hazekamp TH. 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.
Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.
Singh RJ & Jauhar PP. 2005. *Genetic Resources, Chromosomal Engineering and Crop Improvement*. Vol. I. *Grain Legumes*, Vol. II. *Cereals*. CRC Press, Taylor & Francis Group, USA.

2.GP 602 ADVANCED BIOMETRICAL AND QUANTITATIVE GENETICS 2+1

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Basic principles of Biometrical Genetics; Selection of parents; Advanced biometrical models for combining ability analysis; Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes; Designs and Systems; Selection of stable genotypes.

UNIT II

Models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Principal Component Analysis.

UNIT III

Additive and multiplicative model - Shifted multiplicative model; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping enotypes.

UNIT IV

Genetic architecture of quantitative traits; Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance – Construction of saturated linkage maps, concept of framework map development; QTL mapping- Strategies for QTL mapping - desired populations, statistical methods; Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods.

Practical

Working out efficiency of selection methods in different populations and interpretation - Biparental mating – use of softwares in analysis and result interpretation - Triallel analysis– use of softwares in analysis and result interpretation - Quadriallel analysis – use of softwares in analysis and result interpretation - Triple Test Cross (TTC) – use of softwares in analysis and result interpretation - Advanced biometrical models for combining ability analysis - Selection of stable genotypes using stability analysis; Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods

and steps to select the best model - Selection systems - Biplots and mapping genotypes. Construction of
linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies.

Suggested Readings

Bos I & P Caligari. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
Falconer DS & Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman.
Mather K & Jinks L. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.
Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.
Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.
Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.
Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection inPlant Breeding*. Walter de Gruyter.

3.GP 603 GENOMICS IN PLANT BREEDING 2+1

Objective

To impart practical skills in advanced molecular techniques in genome mapping structural/functional genomics and development of transgenic crops.

Theory

UNIT I

Introduction to the plant genome- Plant nuclear genomes and their molecular description - The chloroplast and the mitochondrial genomes in plants - Genome size and complexity.

UNIT II

Establishment of plant genome mapping projects - Genome mapping and use of molecular markers in plant breeding; Strategies for mapping genes of agronomic traits in plants- Approaches for mapping quantitative trait loci; Map based cloning of plant genes.

UNIT III

Regulation of Plant gene expression - Functional genomics – Expression Analysis using Microarrays – Transposon tagging and Insertional mutagenesis- methods and significance- Diversity Array Technology.

UNIT IV

Genome sequencing in plants–Principles and Techniques; Applications of sequence information in plant genome analyses; Comparative genomics– Genome Comparison Techniques- Classical and advanced approaches.

UNIT V

Detection of Single Nucleotide Polymorphism; TILLING and Eco-TILLING; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome; Importance of understanding the phenotypes for exploiting the outcome of genomic technologies- Knock out mutant studies and high throughput phenotyping.

UNIT VI

Concept of database development, management and bioinformatics; Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical

Chromosome analysis in major field crops - Fluorescence *in situ* hybridization - Comparative genomic hybridization – Comparative analysis of plant genomes using molecular markers – Genetic map construction using molecular markers – Mapping major genes using molecular markers – QTL mapping in plants – Comparison across mapping populations – Understanding the need genetic algorithms in QTL mapping – Plant Genome Databases – Computational tools to explore plant genome databases – Comparative genomics – Comparison of genome sequencesusing tools of bioinformatics- Advanced genomic technologies: TILLING and Eco-TILLING – DNA Array Technology – Linking genome sequences to phenotypes: Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings

Baxevanis AD & Ouellette BFF. 2001. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins.* Wiley Interscience.

Brown TA. 2002. *Genomes*. Wiley-LISS.

Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols,Applications and Overviews*. Wiley-VCH.

Cantor CR & Smith CL (2004). *Genomics*. Wiley, New York.

Galas DJ & McCormack SJ. 2002. *Genomic Technologies: Present andFuture*. Calster Academic Press.

Jordan BR. 2001. *DNA Microarrays: Gene Expression Applications*.Springer-Verlag.

Liu BH. 1997. *Statistical Genomics: Linkage, Mapping and QTL Analysis*CRS Press.

Lynch M & Walsh B. 1998. *Genetics and Analysis of Quantitative Traits*.Sinauer Associates.

Mount DW. 2001. *Bioinformatics. Sequence and Genome Analysis*. ColdSpring Harbor Laboratory Press..

Palzkill T. 2002. *Proteomics*. Kluwer.

Paterson AH. 1996. *Genome Mapping in Plants*. Academic Press.

Pennington SR & Dunn MJ. 2002. *Proteomics: From Protein Sequence toFunction*. Viva Books.

Rampal JB. 2001. *DNA Arrays: Methods and Protocols*. Humana Press.

4.GP 604 MOLECULAR AND CHROMOSOMAL MANIPULATIONS FOR CROP BREEDING 2+0

Objective

This course focuses on the advanced techniques in analyzing chromosome structure and manipulations for genome analysis in crop species.

Theory

UNIT I

Organization and structure of genome – Genome size – Organization of organellar genomes – Nuclear DNA organization – Nuclear and Cytoplasmic genome interactions and signal transduction; Transcriptional and Translational changes, Inheritance and expression of organellar DNA; Variation in DNA content – C value paradox; Sequence complexity – Introns and Exons – Repetitive sequences – Role of repetitive sequence.

UNIT II

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/genomic segments; Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids.

UNIT III

Applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchangegenetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods; Duplication - production and use; Inversions and location of genes; B/A chromosome translocations and gene location.

UNIT IV

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomicsmethods of production, breeding behaviour and location of genes; Intervarietal substitutions-allelic and non-allelic interactions; Telocentric method of mapping.

UNIT V

Barriers to interspecific and intergeneric hybridization- Behaviour of interspecific and intergeneric crosses; Totipotency of cells – Morphogenesis: *in vivo* and *in vitro* – Meristem culture – anther and pollen culture – ovule, ovary, embryo and endosperm culture – protoplast isolation and culture – protoplast fusion, Different pathways of *in vitro* morphogenesis – organogenesis and somatic embryogenesis; *in vitro* mutant/somaclone selection for biotic and abiotic stresses.

Suggested Readings

Clark MS & Wall WJ. 1996. *Chromosomes: The Complex Code*. Chapman & Hall.

Conger BV. (Ed.). 1981. *Cloning Agricultural Plants via in vitro Techniques*. CRC Press.

Constabel F & Vasil IK. (Eds.). 1988. *Cell Culture and Somatic Cell Genetics of Plants*. Vol. V. *Cell Culture and Phytochemicals in Plant Cell Cultures*. Academic Press.

Lal R & Lal S. (Eds.). 1990. *Crop Improvement Utilizing Biotechnology*. CRC Press.

Mantel SH & Smith H. 1983. *Plant Biotechnology*. Cambridge University Press.

Sen SK & Giles KL. (Eds.). 1983. *Plant Cell Culture in Crop Improvement*.
Plenum Press.

5. GP 605 ADVANCED IN PLANT BREEDING SYSTEMS 2+0

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Facts about plant breeding before the discovery of Mendelism; Evolutionary concepts of genetics and plant breeding - Flower development and its importance; genes governing the whorls formation and various models proposed; Mating systems and their exploitation in crop breeding; Types of pollination, mechanisms promoting cross pollination.

UNIT II

Self- incompatability and sterility – Types of self incompatability: Homomorphic (sporophytic and gametophytic) and heteromorphic - Breakdown of incompatibility - Floral adaptive mechanisms - Spatial and temporal - Genetic and biochemical basis of self incompatibility; Sterility: male and female sterility – Types of male sterility: genic, cytoplasmic and cytoplasmic-genic; Exploitation in monocots and dicots, difficulties inexploiting CGMS system in dicots – Case studies and breeding strategies;

Nucleocytoplasmic interactions with special reference to male sterility – Genetic , biochemical and molecular bases.

UNIT III

Population formation by hybridization - Types of populations – Mendelian population, gene pool, composites, synthetics etc.; Principles and procedures in the formation of a complex population; Genetic basis of population improvement.

UNIT IV

Selection in self fertilizing crops; Creation of genetic variability selection methods - Selection methods: mass selection, pureline selection, pedigree method (selection in early generations vs advanced generations); Backcross, polycross and test cross.

UNIT V

Selection in cross fertilizing crops – Polycross and topcross selections, Mass and recurrent selection methods and their modifications – Mass selection: grided mass selection, ear to row selection, modified ear to row selection; Convergent selection, divergent selection; Recurrent selection: Simple recurrent selection and its modifications (restricted phenotypic selection, selfed progeny selection and full sib recurrent selection) - Recurrent selection for general combining ability (GCA) – Concepts and utilization - Recurrent selection for specific combining ability (SCA) – usefulness in hybrid breeding programmes - Reciprocal recurrent selection (Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and Full sib reciprocal recurrent selection); Selection in clonally propagated crops – Assumptions and realities.

UNIT VI

Genetic engineering technologies to create male sterility; Prospects and problems - Use of self- incompatability and sterility in plant breeding – case studies; - Fertility restoration in male sterile lines and restorer diversification programmes - Conversion of agronomically ideal genotypes into male steriles – Concepts and breeding strategies; Case studies - Generating new cytonuclear interaction system for diversification of male

steriles - Stability of male sterile lines – Environmental influence on sterility– Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding - Temperature sensitive genetic male sterility and its use heterosis breeding - Apomixis and its use in heterosis breeding - Incongruity – Factors influencing incongruity - Methods to overcome incongruity mechanisms.

Suggested Readings

Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.

Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.

Briggs FN & Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.

Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.

Hayes HK, Immer FR & Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.

Mandal AK, Ganguli PK & Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.

Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani.

Singh P. 1996. *Essentials of Plant Breeding*. Kalyani.

Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

Williams W. 1964. *Genetical Principles and Plant Breeding*. Blackwell.

6.GP 606 CROP EVOLUTION 2+0

Objective

To impart knowledge on crop evolutionary aspects and manipulation at ploidy level for crop improvement.

Theory

UNIT I

Origin and evolution of species; Centres of diversity/origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies.

UNIT II

Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift - Consequences.

UNIT III

Speciation and domestication – The process of speciation – Reproductive isolation barriers – Genetic differentiation during speciation – Hybridization - speciation and extinction.

UNIT IV

Exploitation of natural variation – Early attempts to increase variation – Distant hybridization and introgression- Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.

UNIT V

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution – Multifactorial genome – Intragenomic interaction –Intergenomic interaction – Genome introgression.

UNIT VI

Methods to study crop evolution - Contemporary Methods – Based on morphological features – Cytogenetic analysis – Allozyme variations and crop evolution – DNA markers, genome analysis and comparative genomics.

UNIT VII

Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations; polyploids: methods, use of autopolyploids; haploidy-method of production and use; allopolyploids- synthesis of new crops; - Case studies – Cereals – Pulses – Oilseeds – vegetables, Fibre crops - Plantation crops – Forage crops – Tuber crops – Medicinal Plants.

Suggested Readings

Hancock JF. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.
Ladizinsky G. 1999. *Evolution and Domestication*. Springer.
Miller AJ. 2007. *Crop Plants: Evolution*. John Wiley & Sons.
Smartt J & Simmonds NW. 1995. *Evolution of Crop Plants*. Blackwell.

7. GP 607 BREEDING DESIGNER CROPS 2+1

Objective

To impart theoretical knowledge and practical know-how towards physiological efficiency, nutritional enhancement, biofortification and industrial/pharma applications in plant breeding.

Theory

UNIT I

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats. UNIT II

Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement.

UNIT III

Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

UNIT IV

Breeding for special traits viz. oil, protein, vitamins, amino acids etc.; Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming

UNIT V

Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management

Practical

Demonstration of plant responses to stresses through recent techniques; Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/drought/salt shock proteins.

Suggested Readings

Balint A. 1984. *Physiological Genetics of Agricultural Crops*. AK Ademiaikiado.
Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
Pessarakli M. 1995. *Handbook of Plant and Crop Physiology*. Marcel Dekker.
Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

8.GP 608 ADVANCES IN BREEDING OF MAJOR CROPS 3+0

Objective

To provide insight into recent advances in improvement of cereals and pulses,oil yielding crops,tuber crops.perennial crops,vegetables,medicinal and aromatic and ornamentals using conventional and modern biotechnological approaches.

Theory

UNIT I

History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non cereal crops like Rice, Wheat, Maize, Pearlmillet, Sorghum , Pulses, oilseeds, cotton, sugarcane, arid legumes and others.Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship – Breeding objectives-yield, quality characters, biotic and abiotic stress resistance *etc.* – Hybrid rice breeding-potential and outcome - Aerobic rice, its implications and drought resistance breeding.

UNIT II

Wheat: Evolution and distribution of species and forms - wild relatives and germplasm; cytogenetics and genome relationship; Breeding objectivesyield, quality characters,

biotic and abiotic stress resistance, exploitation of heterosis etc; Sorghum: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc; Pearl millet: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc.

UNIT III

Maize: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectivesyield, quality characters, biotic and abiotic stress resistance etc.

UNIT III

Other pulses: Greengram, blackgram, fieldpea, frenchbean,cowpea,horsegram,cowpea,lablab, Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

UNIT IV

Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress etc. Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT V

Other oilseed crops: Sunflower, sesame,: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements.

UNIT V1

Perennial crops Coconut, arecanut, rubbers, cashew cardamom, blackl peper.
Evolution and distribution of species and forms. Cytogenetics, breeding objectives – field and quality: conventional and modern breeding approaches, achievements hybrid varieties.Tropical tuber crops – Tapioca, Sweet potato, yam, colocasia: Evolution distribution of forms and species, classification, cytogenetics, breeding objectives yield and quality, breeding methods, achievements.

Unit V1I

Medicinal and aromatic plants, Ornamental plants Orchid, Anthurium. Distribution of forms and species – cytogenetics, breeding objectives, breeding methods and achievements.Medicinal plants: Lemongrass eucalyptus *Oscimum*, *Piper longum*, *Kaempferia*, *Sida* spp. and other important tree medicinal plants, origin, distribution of species and forms, cytogenetics breeding objectives yield and quality, breeding methods, achievement.

UNIT V111

Vegtables, evolution and distribution of species and forms – wild relatives and germplasm, Cytogenetics and genome relationship – Breeding objects – yield, quality

characters, biotic and abiotic stress resistance etc. in important vegetable crops. Fruit – Crops : Mango and Banana origin, distribution of species and forms, cytogenetics, breeding objectives, yield and quality, breeding methods, achievement

UNIT IX

Breeding objectives in rice, wheat, maize, pearlmillet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

UNIT X

Breeding for value addition and resistance to abiotic and biotic stresses.Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics.

UNIT X1

National and International accomplishments in genetic improvement of major field crops and their seed production.Breeding objectives in rice, wheat, maize, pearlmillet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

Practical

Floral biology – emasculation - pollination techniques ; Study of range of variation for yield and yield components – Study of segregating populations and their evaluation - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; Use of softwares for database management and retrieval.Practical learning on the cultivation of cereals,pulses,oil seeds,fruit crops,vegetables,medicinal plants,perennials.

Suggested Readings

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.

Chandraratna MF. 1964. *Genetics and Breeding of Rice*. Longmans.

Chopra VL & Prakash S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH.

Gill KS. 1991. *Pearl Millet and its Improvement*. ICAR.

IRRI. 1964. *Rice Genetics and Cytogenetics*. Elsevier.

IRRI. 1986. *Rice Genetics*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

IRRI. 1991. *Rice Genetics II*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

IRRI. 1996. *Rice Genetics III*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

IRRI. 2000. *Rice Genetics IV*. Proc. International Rice Genetics Symposium.
IRRI, Los Banos, Manila, Philippines.

Jennings PR, Coffman WR & Kauffman HE. 1979. *Rice Improvement*.
IRRI, Los Banos, Manila, Philippines.

Kannaiyan S, Uthamasamy S, Theodore RK & Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*.
Directorate of Extension Education, TNAU, Coimbatore.

Murty DS, Tabo R & Ajayi O. 1994. *Sorghum Hybrid Seed Production and Management*. ICRISAT, Patancheru, India.

Nanda JS. 1997. *Manual on Rice Breeding*. Kalyani.

Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.

Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994.
Crop Breeding in India. International Book Distributing Co.
Slafer GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.28
Walden DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.
Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.
Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.
Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 30
Nath V & Lal C. 1995. *Oilseeds in India*. Westvill Publ. House.
Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.
Singh DP. 1991. *Genetics and Breeding of Pulse Crops*. Kalyani.
Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. *Crop Breeding in India*. International Book Distributing Co.
Smartt J. 1994. *The Groundnut Crop - a Scientific Basis for Improvement*. Chapman & Hall
Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.
Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.
Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 30
Nath V & Lal C. 1995. *Oilseeds in India*. Westvill Publ. House.
Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.
Singh DP. 1991. *Genetics and Breeding of Pulse Crops*. Kalyani.
Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. *Crop Breeding in India*. International Book Distributing Co.
Smartt J. 1994. *The Groundnut Crop - a Scientific Basis for Improvement*. Chapman & Hall
Basset. M.J.(Ed.) 1986. Breeding vegetable Crops A VI publications
Feria. M.S, Arya. P.S. and Choudhary a.k. 2000Vegetable Crops Breeding and Seed Production Vol, I Kalyani.
Kalloo. G. 1988. Vegetable Breeding Vols. I – III – CRC Press
Kalloo.G.1998. Vegetable Breeding Vols. I – III (Combined Ed.) Panima Edn. Book Agency.
Kumar I.C. and Dhaliwal. M.S. 1990. Technics of Developing Hybrids in Vegetable Crops. Agro Botanical Publications.
Singh P.K./, Dasgupta S.K. and Tripathi.S.K. 2004. Hybrid Vegetable Development International Book Distributing Co.
Chopra VL. 2001. *Breeding Field Crops - Theory and Practice*. Oxford &IBH.
Davis DD.1978. *Hybrid Cotton Specific Problems and Potentials*. Adv.Agron. 30: 129-157.
Heyne EG. 1987. *Wheat and Wheat Improvement*. 2nd Ed. ASA, CSSA,SSSA Inc Publ.
Khairwal, IS, Rai KN & Harinaryanan H. (Eds.). 1999. *Pearl MilletBreeding*. Oxford & IBH.
Khairwal I, Ram C & Chhabra AK. 1990. *Pearl Millet Seed Productionand Technology*. Manohar Publ.

Nagarajan S, Singh G & Tyagi BS. 1998. *Wheat Research Needs Beyond2000 AD*. Narosa.
Nanda JS. 2000. *Rice Breeding and Genetics - Research Priorities andChallenges*. Oxford & IBH.
Rao VS, Singh G & Misra SC. 2004. *Wheat: Technologies for WarmerAreas*.Annamaya Publ.
Reynolds MP, Rajaram S, McNab A. 1996. *Increasing Yield Potential inWheat: Breaking the Barriers*. Proc. Workshop held in Ciudad,Obregon, Sonora, Mexico.
Seth BL, Sikka SM, Dastur RH, Maheshwari P, Rangaswamy NS & JosiAB. 1960. *Cotton in India – A Monograph*. Vol. I. ICAR.
Singh BD. 2006. *Plant Breeding - Principles and Methods*. Kalyani.
Singh P & Singh S. 1998. *Heterosis Breeding in Cotton*. Kalyani.
Singh P. 1998. *Cotton Breeding*. Kalyani.
Singh S & Singh P. 2006. *Trends in Wheat Breeding*. Kalyani Publ.

9.GP 609 MICROBIAL GENETICS 2+1

Objective

The objective of this course is to apprise the students of molecular processes at DNA and RNA level in different microorganisms, especially bacteria and viruses.

Theory

UNIT I

Nature of bacterial variation; Molecular aspects of mutation; Episomes and plasmids; Gene mapping in bacteria; Life cycle of bacteriophages; Genetic fine analysis of rII locus; Circular genetic map of phage T4; Transposable elements; Gene manipulation; Biochemical genetics of *Neurospora and Sacharomyces* ; One gene - one enzyme hypothesis.

UNIT II

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Molecular chaperones and gene expression; Genetic basis of apoptosis.

UNIT III

Transgenic bacteria and bioethics; genetic basis of nodulation, nitrogen fixation and competition by rhizobia, genetic regulation of nitrogen fixation and quorum sensing in rhizobia; genetics of mitochondria and chloroplasts.

Practical

Preparation and sterilization of liquid and agar bacterial nutrient media; Assessment of generation time in the log-phage bacterial cultures.Handling of microorganisms for genetic experiments; Isolation of rhizobia from nodules; Gram staining of rhizobial cells; Examination of polyhydroxy butyrate (PHB) production in rhizobia; Demonstration of N2- fixing nodules/bacterial inoculation in the legume- *Rhizobium* symbiotic system. Induction, isolation and characterization of auxotrophic and drug resistant mutants in bacteria; determination of spontaneous and induced mutation frequencies; Discrete bacterial colony counts for the preparation of survival curves and determination of LD50 of a mutagen. Tn-mediated mutagenesis; Analysis and isolation of plasmid DNA; Curing of plasmids.

Suggested Readings

Brooker RJ. 2004. *Genetics Analysis and Principles*. Addison-Wesley Longman.
Brown TA. 2002. *Genomes.* Bios Scientific Publ.
Griffiths AJF. 2000. *An Introduction to Genetic Analysis*. WH Freeman.
Hexter W & Yost HT 1976. *The Science of Genetics*. Prentice Hall.

Karp G. 2004. *Cell and Molecular Biology: Concepts and Experiments*.John Wiley.
Lewin B. 2008. Genes IX. John Wiley & Sons.
Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.
Schleif R.1986. *Genetics and Molecular Biology*. Addison-Wesley Publ.Co.
Tamarin RH. 1999. *Principles of Genetics*. Wm C Brown Publ.
Watson JD. 2004. *Molecular Bilology of the Gene*. Pearson Edu.
Yadav AS, Vasudeva M, Kharab P & Vashishat RK. 2002. *PracticalManual on Microbial and Molecular Genetics*. Dept. of Genetics,CCS HAU Hisar.

10.GP 610 *IN SITU* AND *EX SITU* CONSERVATION 2+1
OF GERMPLASM

Objective
To impart knowledge on the methods of germplasm conservation.
Theory
UNIT I
Concept of natural reserves and natural gene banks, *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conservedgenetic diversity on-farm, enhancing benefits for farmers from local crop diversity.
UNIT II
Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, *perma-frost* conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling ,clonal repositories, genetic stability under long term storage condition.
UNIT III
In vitro storage, maintanence of *in vitro* culture under different conditions, *in vitro* bank maintanence for temporate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in vitro* gene bank.
UNIT IV
Cryopreservation- procedure for handling seeds of orthodox and recalcitrants-cryoprotectants,dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agriculture, horticulture and forestry crops.Problems and prospects; challenges ahead.
Practical
In situ conservation of wild species –case studies at national and international levels- *ex situ* techniques for active and long-term conservation of collections- Preparation and handling of materials, packaging, documentation; design of cold storage modules-Conservation protocols for recalcitrant and orthodox seeds; Cytological studies forassessing genetic stability, *in vitro* cultures- embryo,cell/suspension cultures,pollen cultures, study of cryotank facility and vitrification techniques, visit to NBPGR/NBAGR -study using fruit crops and other horticultural crops.

Suggested Readings

Ellis RH & Roberts EH & White Head J. 1980. *A New More Economicand Accurate Approach to Monitor the Viability of AccessionsDuring Storage in Seed Banks*. FAO / IBPGR Pl. Genet. ResourcesNews 41-3-18.

Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today andTomorrow*. Cambridge University Press, Cambridge.

Simmonds, N.W. 1979. *Principles of Crop Improvement* Longman.

Westwood MN. 1986. *Operation Manual for National Clonal GermplasmRepository Processed Report*. USDA-ARS and Orgon State Univ.Oregon, USA.

Withers LA. 1980. *Tissue Culture Storage for Genetic Conservation*.IBPGR Tech. Rep. IBPGR, Rome, Italy.

AGRICULTURAL ENTOMOLOGY

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
ENT 501*	INSECT MORPHOLOGY	1+1
ENT 502*	INSECT ANATOMY, PHYSIOLOGY AND NUTRITION	2+1
ENT 503*	INSECTS SYSTEMATICS	2+1
ENT 504	INSECT ECOLOGY	1+1
ENT 505	INSECT PATHOLOGY	1+1
ENT 506	BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS	1+1
ENT 507	TOXICOLOGY OF INSECTICIDES	2+1
ENT 508	PLANT RESISTANCE TO INSECTS	1+1
ENT 509*	PRINCIPLES OF INTEGRATED PEST MANAGEMENT (Ag. Stat. also)	1+1
ENT 510	PESTS OF FIELD CROPS	1+1
ENT 511*	PESTS OF HORTICULTURAL AND PLANTATION CROPS	1+1
ENT 512	STORAGE ENTOMOLOGY	1+1
ENT 513	INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS	1+1
ENT 514	GENERAL ACAROLOGY	1+1
ENT 515	SOIL ARTHROPODS AND THEIR MANAGEMENT	1+1
ENT 516	VERTEBRATE PEST MANAGEMENT	1+1
ENT 517	TECHNIQUES IN PLANT PROTECTION	0+1
ENT 518	COMMERCIAL ENTOMOLOGY I (PRODUCTIVE INSECTS)	1+1
ENT 519	COMMERCIAL ENTOMOLOGY II (URBAN ENTOMOLOGY)	1+1
ENT 520	PLANT NEMATOLOGY	2+1
ENT 521	NEMATOLOGICAL TECHNIQUES	1+1
ENT 522	NEMATODE PESTS OF AGRICULTURAL CROPS AND THEIR MANAGEMENT	1+1
ENT 523	BIOTECHNOLOGY IN NEMATODE MANAGEMENT	1+1
ENT 524	INTRODUCTORY AND ECONOMIC ENTOMOLOGY (Ag. Stat. only)	1+1
ENT 591	MASTER'S SEMINAR	0 +1
ENT 599	MASTER'S RESEARCH	20
ENT 601	ADVANCED INSECT SYSTEMATICS	1+2
ENT 602	IMMATURE STAGES OF INSECTS	1+1
ENT 603	ADVANCED INSECT PHYSIOLOGY	2+0
ENT 604	ADVANCED INSECT ECOLOGY	1+1
ENT 605	INSECT BEHAVIOUR	1+1
ENT 606	RECENT TRENDS IN BIOLOGICAL CONTROL	1+1
ENT 607	ADVANCED INSECTICIDE TOXICOLOGY	2+1

ENT 608	ADVANCED HOST PLANT RESISTANCE	1+1
ENT 609	ADVANCED ACAROLOGY	1+1
ENT 610	AGRICULTURAL ORNITHOLOGY	1+1
ENT 611**	MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH	1+1
ENT 612**	ADVANCED INTEGRATED PEST MANAGEMENT	2+0
ENT 613	PLANT BIOSECURITY AND BIOSAFETY	2+0
ENT 614	NEMATODE MORPHOLOGY AND TAXONOMY	2+1
ENT 615	NEMATODE ECOLOGY AND CONTROL	2+1
ENT 691	DOCTORAL SEMINAR I	1+0
ENT 692	DOCTORAL SEMINAR II	1+0
ENT 699	DOCTORAL RESEARCH	45

Compulsory for Master's programme; ** Compulsory for Ph.D. programme

1. ENT 501 INSECT MORPHOLOGY 1+1

Objective

To acquaint the students with external morphology of the insect's body i.e., head, thorax and abdomen, their appendages and functions.

Theory

UNIT I

Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

UNIT II

Head- Origin, **s**tructure and modification; types of mouthparts and antennae, tentorium and neck sclerites.

UNIT III

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications.

UNIT IV

Abdomen- Segmentation and appendages; Genitalia and their modifications; Embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs (mechano - photo- and chemoreceptors).

Practical

Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia.Sense organs.

Suggested Readings

Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.

David BV & Ananthkrishnan TN. 2004. *General and Applied Entomology*. Tata-McGraw Hill, New Delhi.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.

Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.

Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.

Saxena RC & Srivastava RC. 2007. *Entomology: At a Glance*. Agrotech Publ. Academy, Jodhpur.

Snodgross RE. 1993. *Principles of Insect Morphology.* Cornell Univ. Press, Ithaca.

2. ENT 502 INSECT ANATOMY, PHYSIOLOGY AND NUTRITION 2+1

Objective

To impart knowledge to the students on basic aspects of anatomy of different systems, elementary physiology, nutritional physiology and their application in entomology.

Theory

UNIT I

Scope and importance of insect anatomy and physiology.

UNIT II

Structure, modification and physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands.

UNIT III

Thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapause.

UNIT IV

Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

Practical

Dissection of different insects to study comparative anatomical details of different systems; preparation of permanent mounts of internal systems; chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

Suggested Readings

Chapman RF.1998. *Insects: Structure and Function*. ELBS Ed., London.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.

Kerkut GA & Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology.* Vols. I-XIII. Pergamon Press, New York.

Patnaik BD. 2002. *Physiology of Insects*. Dominant, New Delhi.

Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Vol. 1. *Structure, Physiology and Development.* Chapman & Hall, New York.

Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.

Wigglesworth VB.1984. *Insect Physiology*. 8th Ed. Chapman & Hall, New York.

3. ENT 503 INSECT SYSTEMATICS 2+1

Objective

To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects.

Theory

UNIT I

Principles of Biological classification. Nomenclature International code of Zoological Nomenclature.

UNIT II

Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- Orders contained.

UNIT III

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them. Collembola, Protura, Diplura.

Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera,

Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

UNIT IV

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

Study of Orders of insects and their identification using taxonomic keys. Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Field visits to collect insects of different orders.

Suggested Readings

CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.

Freeman S & Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.

Ross HH.1974. *Biological Systematics.* Addison Wesley Publ. Co.

Triplehorn CA & Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects*. 7th Ed. Thomson/ Brooks/ Cole, USA/Australia.

4. ENT 504 INSECT ECOLOGY 1+1

Objective

To teach the students the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, organization of communities, diversity indicies. Train students in sampling methodology, calculation of diversity indicies, constructing life tables, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

UNIT I

History and Definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

UNIT II

Basic concepts of abundance- Model vs Real world. Population growth basic models – Exponential vs Logistic models. Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental

factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality Diapause (Quiescence) - aestivation, hibernation.

UNIT III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Intraspecific and interspecific interactions- Basic factors governing the interspecific interactions - Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of nicheecological homologues, competitive exclusion. Prey-predator interactions - Basic model- Lotka - Volterra Model, Volterra's principle. Functional and numerical response. Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

UNIT IV

Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's *d/w*, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology.

Practical

Types of distributions of organisms. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's Disc equation, Assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild. Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of some diversity indices Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Suggested Readings

Chapman JL & Reiss MJ. 2006. *Ecology: Principles & Applications*. 2nd Ed. Cambridge Univ. Press, Cambridge.

Gotelli NJ & Ellison AM. 2004. *A Primer of Ecological Statistics.* Sinauer Associates, Inc., Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology.* 3rd Ed. Sinauer Associates, Inc., Sunderland, MA

Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.

Krebs CJ. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.

Krebs CJ. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance.* 5th Ed. Benjamin-Cummings Publ. Co., New York.

Magurran AE. 1988. *Ecological Diversity and its Measurement.* Princeton Univ. Press, Princeton.

Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.

Real LA & Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.

Southwood TRE & Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Methuen & Co. Ltd., London.

Speight MR, Hunta MD & Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.
Wilson EO & William H Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.
Wratten SD & Fry GLA.1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

5. ENT 505 INSECT PATHOLOGY 1+1

Objective
To teach the students about various microbes that are pathogenic to insects, factors that affect their virulence; provide hands - on training in identification, isolation, culturing various pathogens and assessing pathogenicity.

Theory
UNIT I
History and scope of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.
UNIT II
Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.
UNIT III
Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens. Safety and registration of microbial pesticides. Use of insect pathogens in integrated management of insect pests. Genetic engineering of entomopathogen.

Practical
Familiarization with equipment used in insect pathology laboratory. Identification of different groups of insect pathogens and symptoms of infection. Isolation, culturing and testing pathogenicity of different groups of pathogens. Testing Koch's postulates. Estimation of pathogen load. Extraction of pathogens from live organisms and soil. Bioassays to determine median lethal doses.

Suggested Readings
Boucias DG & Pendland JC. 1998. *Principles of Insect Pathology.* Kluwer Academic Publisher, Norwel.
Burges HD & Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.
Steinhaus EA. 1984. *Principles of Insect Pathology.* Academic Press, London.

6. ENT 506 BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS 1+1

Objective
To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory

UNIT I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control - importation, augmentation and conservation.

UNIT II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects.

UNIT III

Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation.

UNIT IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Suggested Readings

Burges HD & Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman & Hall, New York.

Dhaliwal GS & Arora R. 2001. *Integrated Pest Management: Concepts and Approaches.* Kalyani Publ., New Delhi.

Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual.* Chapman & Hall, New York.

Huffaker CB & Messenger PS. 1976. *Theory and Practices of Biological Control.* Academic Press, London.

Ignacimuthu SS & Jayaraj S. 2003. *Biological Control of Insect Pests*. Phoenix Publ., New Delhi.

Saxena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.

Van Driesche & Bellows TS. Jr. 1996. *Biological Control*. Chapman & Hall, New York.

7. ENT 507 TOXICOLOGY OF INSECTICIDES 2+1

Objective

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

UNIT I

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

UNIT II

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature. Structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds, etc.

UNIT III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides-synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity.

UNIT IV

Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

UNIT V

Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

Insecticide formulations and mixtures; study of pesticide containers; quality control of pesticide formulations; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Pesticide residue estimation methods; Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides; visit to toxicology laboratories. Good laboratory practices.

Suggested Readings

Chattopadhyay, S.B. 1985. *Principles and Procedures of Plant Protection.* Oxford & IBH, New Delhi.

Gupta, HCL.1999. *Insecticides: Toxicology and Uses.* Agrotech Publ., Udaipur.

Ishaaya I & Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action.* Narosa Publ. House, New Delhi.

Matsumura F. 1985. *Toxicology of Insecticides.* Plenum Press, New York.

Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. *Insecticides in Agriculture and Environment.* Narosa Publ. House, New Delhi.

Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publ., New York.

Sharma, K.K. 2006. *Pesticide Residue Analysis - a complete guide*. ICAR, New Delhi. p.351

8. ENT 508 PLANT RESISTANCE TO INSECTS 1+1

Objective

To familiarize the students with types, basis, mechanisms and genetics of resistance in plants to insects and role of plant resistance in pest management.

Theory

UNIT I

History and importance of resistance, principles, classification, components, types and mechanisms of resistance.

UNIT II

Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

UNIT III

Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance - acquired and induced systemic resistance.

UNIT IV

Factors affecting plant resistance including biotypes and measures to combat them.

UNIT V

Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

UNIT VI

Role of biotechnology in plant resistance to insects- Ecological consequences, Integration of plant resistance with other methods of pest control.

Practical

Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible / resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

Suggested Readings

Dhaliwal GS & Singh R. (Eds). 2004. *Host Plant Resistance to Insects - Concepts and Applications.* Panima Publ., New Delhi.

Maxwell FG & Jennings PR. (Eds). 1980. *Breeding Plants Resistant to Insects.* John Wiley & Sons, New York.

Painter RH.1951. *Insect Resistance in Crop Plants*. MacMillan, London.

Panda N & Khush GS. 1995. *Plant Resistance to Insects.* CABI, London.

Smith CM. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches.* Springer, Berlin.

9. ENT 509 PRINCIPLES OF INTEGRATED PEST MANAGEMENT 1+1

Objective

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM**.** Train students in sampling of populations of pests, parasites and predators, assessment of crop losses and implementing IPM strategies.

Theory

UNIT I

History and origin, definition and evolution of various related terminologies.

UNIT II

Concept and philosophy, ecological principles, economic threshold concept,and economic consideration.

UNIT III

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses can be detected crop modeling; designing and implementing IPM system.

Suggested Readings

Dent, D. 1991. *Insect Pest Management* . CAB International, Wellingford, UK

Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches.* Kalyani Publ., New Delhi.

Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.

Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management.* 1st Ed., Springer, New York.

Horowitz AR & Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.

Ignacimuthu SS & Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.

Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management.* John Wiley & Sons, New York.

Pedigo RL. 2002. *Entomology and Pest Management.* 4th Ed. Prentice Hall, New Delhi.

Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concepts in Integrated Pest Management.* Prentice Hall, New Delhi.

Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.* Marcel Dekker, New York.

10. ENT 510 PESTS OF FIELD CROPS 1+1

Objective

To familiarize the students about nature of damage and seasonal incidence of pests that causes loss to major field crops and their effective management by different methods.

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect pest, non insect pests (mites, nematodes, rodents, birds, snails, slugs) and vectors.

UNIT I

Pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars etc.

UNIT II

Pests of pulses, tobacco, oilseeds and their management.

UNIT III

Pests of fibre crops, forages, sugarcane and their management.

Practical

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

Suggested Readings

Atwal AS, Dhaliwal GS & David BV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.

Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publ., New Delhi
Evans JW. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.
Nair MRGK. 1986. *Insect and Mites of Crops in India.* ICAR, New Delhi.
Prakash I & Mathur RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.
Saxena RC & Srivastava RC. 2007. *Entomology at a Glance.* Agrotech Publ. Academy, Jodhpur.

11. ENT 511 PESTS OF HORTICULTURAL AND PLANTATION CROPS 1 +1

Objective

To impart knowledge on major pests of horticultural and plantation crops regarding the biology and bionomics extent and nature of loss, seasonal history, their integrated management.

Theory

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect and non insect pests of various crops.

UNIT I

Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

UNIT II

Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables etc.

UNIT III

Plantation crops- coffee, tea, rubber, coconut, arecanut, cashew, oil palm, date palm, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, cinnamon, turmeric, ginger, betlevine etc.

UNIT IV

Ornamental, medicinal and aromatic plants and pests in polyhouses/protected cultivation.

Practical

Collection and identification of important pests and their natural enemies on different crops; study of life history of important insect pests and noninsect pests.

Suggested Readings

Atwal AS & Dhaliwal GS. 2002. *Agricultural Pests of South Asia and theirManagement.* Kalyani Publ., New Delhi.
Butani DK & Jotwani MG. 1984. *Insects and Vegetables.* Periodical Expert Book Agency, New Delhi.
Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publ., New Delhi.
Srivastava RP.1997. *Mango Insect Pest Management.* International Book Distr., Dehra Dun.
Verma LR, Verma AK & Goutham DC. 2004. *Pest Management in Horticulture Crops : Principles and Practices*. Asiatech Publ., New Delhi.

12. ENT 512 STORAGE ENTOMOLOGY 1+1

Objective

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory

UNIT I

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto visà- vis* total production of food grains in India. Scientific and socio-economic factors responsible for grain losses.

UNIT II

Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

UNIT III

Ecology of insect pests of stored commodities/grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

UNIT IV

Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/sanitation, disinfestations of stores/receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control- prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Integrated approaches to stored grain pest management.

Practical

Collection, identification and familiarization with the stored grains/seed insect pests and nature of damage caused by them; detection of insect infestation in stored food grains; estimation of losses in stored food grains; determination of moisture content in stored food grains; familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques; treatment of packing materials and their effect on seed quality. Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, IGSMRI, Hapur etc. (only where logistically feasible).

Suggested Readings

Hall DW. 1970. *Handling and Storage of Food Grains in Tropical and Subtropical Areas.* FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.

Jayas DV, White NDG & Muir WE. 1995. *Stored Grain Ecosystem.* Marcel Dekker, New York.

Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publ., New Delhi.

Khare BP. 1994. *Stored Grain Pests and Their Management.* Kalyani Publ., New Delhi.
Subramanyam B & Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products.* Marcel Dekker, New York.

13. ENT 513 INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS 1+1

Objective
To teach the students about the different groups of insects that vector plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

Theory
UNIT I
History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.
UNIT II
Transmission of plant viruses and fungal pathogens. Modes of transmission. Relation between viruses and their vectors.
UNIT III
Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.
UNIT IV
Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.
UNIT V
Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical
Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leaf hoppers and whiteflies.

Suggested Readings
Basu AN. 1995. *Bemisia tabaci* (Gennadius) - *Crop Pest and Principal Whitefly Vector of Plant Viruses.* Oxford & IBH, New Delhi.
Harris KF & Maramarosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.
Maramorosch K & Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.
Youdeovei A & Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

14. ENT 514 GENERAL ACAROLOGY 1+1

Objective
To aquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

Theory

UNIT I

History of Acarology; importance of mites as a group; habitat, collection and preservation of mites.

UNIT II

Introduction to morphology and biology of mites and ticks. Broad classification major orders and important families of Acari including diagnostic characteristics.

UNIT III

Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens *etc*. Culturing of phytophagous, parasitic and predatory mites.

Practical

Collection of mites from plants, soil and animals; extraction of mites from soil, plants and stored products; preparation of mounting media and slide mounts; external morphology of mites; identification of mites up to family level using keys; studying different rearing techniques for mites.

Suggested Readings

Chhillar BS, Gulati R & Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.

Gerson U & Smiley RL. 1990. *Acarine Biocontrol Agents - An Illustrated Key and Manual*. Chapman & Hall, NewYork.

Gupta SK. 1985. *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta.

Gwilyn O & Evans GO. 1998. *Principles of Acarology*. CABI, London.

Jeppson LR, Keifer HH & Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.

Krantz GW. 1970. *A Manual of Acarology.* Oregon State Univ. Book Stores, Corvallis, Oregon.

Qiang Zhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control*. CABI, London.

Sadana GL. 1997. *False Spider Mites Infesting Crops in India.* Kalyani Publ. House, New Delhi.

Walter DE & Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviou*r. CABI, London.

15. ENT 515 SOIL ARTHROPODS AND THEIR MANAGEMENT 1+1

Objective

To impart knowledge about the different groups of arthropods found in soil, interaction between the different groups, and role of soil arthropods in humus formation. Hands-on training in sampling and identification of different groups of soil arthropods.

Theory

UNIT I

Soil arthropods and their classification, habitats and their identification.

UNIT II

Estimation of populations; sampling and extraction methods.

UNIT III

Role of soil arthropods in detritus feeding, litter breakdown and humus formation. Soil arthropods as bio-indicators of habitat qualities. Effect of soil arthropod activity on soil properties.

UNIT IV

Harmful and beneficial soil arthropods and their management, interrelationship among arthropods and other soil invertebrates and soil microorganisms. Anthropogenic effects on soil arthropods.

Practical

Sampling, extraction methods and identification of various types of soil fauna; estimation and assessment of soil arthropod population; techniques and culturing soil invertebrates.

Suggested Readings

Anderson JM & Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.

Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley & Sons, New York.

Pankhurst C, Dube B & Gupta, V. 1997. *Biological Indicators of Soil Health.* CSIRO, Australia.

Veeresh GK & Rajagopal D.1988. *Applied Soil Biology and Ecology*. Oxford & IBH Publ., New Delhi.

16. ENT 516 VERTEBRATE PEST MANAGEMENT 1+1

Objective

To impart knowledge on life cycle, damage caused and management of vertebrate pests like birds, rodents and other mammals etc.

Theory

UNIT I

Vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals. Biology of beneficial birds.

UNIT II

Population dynamics and assessment, patterns of pest damage and assessment, roosting and nesting systems in birds.

UNIT III

Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and

other eco-friendly methods- Operational practices- baiting, bioassays (LD50 studies), equipments and educative programmes.

Practical

Identification of important rodent and other vertebrate pests of agriculture, food preference and hoarding, social behaviour, damage assessment, field survey, population estimation, control operation and preventive methods.

Suggested Readings

Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay.

Fitzwater WD & Prakash I. 1989. *Handbook of Vertebrate Pest Control.* ICAR, New Delhi.

Parvatha Reddy .P. Abraham Varghese and Krishna Kumar. N.K. 2001, *Integrated Pest Management in Horticultural Ecosystems.* Capital publishing Company, Delhi.

Prakash I & Ghosh PK.1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.

Prakash I & Mathur RP.1987. *Management of Rodent Pests.* ICAR, NewDelhi.

Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay.
Ramesa and Renjith. 2008. Rats and their management. Kerala Agricultural University. Thrissur.

17. ENT 517 TECHNIQUES IN PLANT PROTECTION 0+1

Objective

To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, electrophoresis etc.

Theory

UNIT I

Pest control equipments, principles, operation, maintenance, selection, application of pesticides and biocontrol agents, seed dressing, soaking, root-dip treatment, dusting, spraying, application through irrigation water.

UNIT II

Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers.

UNIT III

Use of light, transmission and scanning electron microscopy.

UNIT IV

Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE.

UNIT V

Use of tissue culture techniques in plant protection. Computer application for predicting/forecasting pest attack and identification.

Suggested Readings

Alford DV. 1999. *A Textbook of Agricultural Entomology*. Blackwell Science, London.
Crampton JM & Eggleston P. 1992. *Insect Molecular Science.* Academic Press, London.

18. ENT 518 COMMERCIAL ENTOMOLOGY I (PRODUCTIVE INSECTS) 1+1

Objective

To familiarize the students with entrepreneurial opportunities in Entomolgy, provide information on productive insects their management and commercialization of products.

Theory

UNIT I

Apiculture

Scope and prospects of beekeeping. History & development of beekeeping in India. Bee keeping equipment, Species and races of bees, bee hive and its characterization. Bee castes, biology, ecology, behavior, communication, foraging strategies. Swarming and absconding. Apiary establishment- beekeeping equipment, bee pasturage, General colony management, seasonal management. Managing colonies for production of honey, other hive products such as Bee pollen, Royal jelly and Bee venom. Artificial queen rearing. Bee health management. Bee poisoning. Production, properties, uses and marketing of good quality honey, bee pollen, royal jelly, propolis, beewax, bee venom,

and value added products of honey. Establishment and maintenance of apiaries. Beekeeping for pollination- role of honey bees in pollinating, agricultural, horticultural and tree crops. Beekeeping in integrated farming systems and organic farming.

UNIT II

Sericulture

History, origin and development, study of different species of silkworms, characteristic features, Host plants and their cultivation, comparative morphology, biology. Rearing and management of silk worms, appliances. Pests and diseases of silkworms, Silk worm seed technology, Cocoon production and post harvest operations. Reeling and testing of silk, marketing. Recent advances in sericulture.

UNIT III

Lac culture

History, origin and development, importance, biology and behavior. Different strains and host plants. Harvesting and processing of lac, lac and its uses, Lac insect natural enemies and their management. Recent advances in lac culture research.

Practical

Identification of honeybee species, bee castes and special adaptations, identification and handling of beekeeping equipments. Hiving natural bee colonies and swarms, Handling of bee hive and colony inspection. Familiarization of bee pasturage, Identification of bee and diseases. Honey extraction and processing, methods of extraction of other hive products. Preparation of beekeeping projects for funding. Visit to bee nursery and commercial apiaries. Silkworm- identification of different species, rearing and management, Identification of diseases and pests of silk worm, host range identification. Lac insect- host and crop management technology and processing of lac. Products and bye- products of lac.

Suggested Readings

Atwal AS, 2006. The World of the Honey Bee, Kalyani Publ, New Delhi.

Mishra R.C 1995. Honey bees and their management in India. ICAR. New Delhi 168p.

Singh S 1975. Beekeeping in India. ICAR, New Delhi

Abrol, D.P 2003. Honey bees diseases and their management. Kalyani Publ, New Delhi.

FAO Mannual on sericulture (1981) VOL. I, II,& III on mulberry cultivation, silk worm rearing and sikl reeling. Oxford and IBH publishing Company. 351p.

Ganga, G. and Sulochana Chetty 1991. Introduction to Sericulture, Oxford and IBH publication 160p. 2003

Comprehensive Sericulture. Vol.II. Silkworm Rearing and Silk Reeling

Aruga H.1994. Principals of Sericulture. Oxford & IBH, New Delhi

Ganga G. 2003. Comprehensive Sericulture. Vol.II> Silkworm Rearing and Silk Reeling. Oxford & IBH, New Delhi.

19. ENT 519 COMMERCIAL ENTOMOLOGY II (URBAN ENTOMOLOGY) 1+1

Objective

To aquaint the students with pest problems in urban and domestic environment and methods to manage them

Theory

UNIT I

Scope and prospects of urban pest management. Pest problems in urban and domestic environment and human habitats.

UNIT II

Economic and public health importance of insect pests in human habitation and habitats. Biology, damage and control of major domestic pests - mosquitoes, houseflies, bed bugs, ants, termites, cockroaches, flies, silverfish, head and body lice, carpet beetles, cloth moths, crickets, wasps, house dust mites. Pests of cattle, poultry, pet animals and their management

UNIT IV

Principles and methods of pest management in residential places and public buildings, insecticides for domestic use and their safety, pre- and post construction termite proofing of buildings, appliances for domestic pest control. Rodent control methods. Organic methods of domestic pest management

Practical

Identification of major pests, vectors in urban conditions. Assessing pest status in dwellings (labs, canteen or hostel), implementation of pest control against flies, mosquitoes, bed bugs, cockroaches and rodents. Pre and post-construction termite proofing methods, control of silverfishes in the library. Visit to poultry units and cattle sheds and assessing pest status. Evaluation of commercially available domestic insect pest control products through bioassays. Rodent control techniques.

Suggested Readings

Ayyar, T.V.R. 1940. Hand book of Entomology for South India. Govt. Press, Madras.

David, B.V. 2001. Elements of Economic Entomology, Popular Book Dept. Madras.

Gupta, R. 2002. Household Pests and their Management. National Book Trust, New Delhi.

Mohan, S. and Sundara Babu. P.C. 2001. Stored Product Pests and their Management, TNAU, Coimbatore.

20. ENT 520 PLANT NEMATOLOGY 2+1

Objective

To impart knowledge to the students on the importance of plant parasitic nematodes, their population dynamics, provide information on the important pests of crops and their management.

Theory

UNIT I

History of plant nematology. Economic importance of plant parasitic nematodes. Taxonomic position of nematodes and their relationship to other soil organisms.

UNIT II

Characters of the Phylum Nematoda. Ecological classification. Factors favouring the incidence of nematodes. Distribution of nematodes. General morphology, biology and physiology of nematodes. Nematode behaviour. Bio-chemical aspects of nematode physiology in relation to host plants.

UNIT III

Principles and practices of nematode management – physical, cultural, biological legal, plant resistance, chemical, integrated nematode management. Important species of nematodes infesting crops.

Practical

Collection of soil and plant parts for nematode extraction. Extraction of nematodes from soil and plant parts. Study of symptoms of damage caused by major plant parasitic forms.Methods of application of nematicides. Identification of common genera of plant parasitic nematodes.

Suggested Readings

Dasgupta, N.K. and Rama, K. 1987. Plant parasitic nematode associated with plantation crops. Review of Tropical Plant Pathology. 4: 289-304

Jonathan, E.I., Cannayane, I., Devrajan, K., Kumar, S. and Ramakrishnan,S. 2005. Agricultural Nematology. Sri Sakthi Promotional Litho Process, Tamil Nadu. 260p.

Jonathan, E.I., Kumar, S., Devrajan, K. and Rajendran, G. 2001. Fundamentals of plant nematology Devi publications, Tamil Nadu. 232p.

Luc, M., Sikora, R.A. and Bridge, J. (Ed.) 1990. Plant parasitic Nematodes in subtropical and tropical Agriculture Cambrian Printers Ltd. Paris. 629p.

Reddy, P.P. 1983. Plant Nematology. Pratibha Printing Press, Sudarshan Park, NewDelhi. 287p.

Saxena, S.K., Khan, W., Rashid, A. and Khan, R.M. 1990. Progress in Plant Nematology. Nazia Printers, Lal Kun, Delhi. 616p.

21. ENT 521 NEMATOLOGICAL TECHNIQUES 1+1

Objective

To aquaint the students with methods of nematode investigations

Theory

UNIT I

Methods of nematode investigations and survey. Collection of soil and plant parts. Extraction of nematodes from soil - Cobb's sieving technique, Baermann's funnel method, elutriation method, sedimentation and sugar floatation technique. Extraction of nematodes from plant parts- root incubation method. Methods of collection of cysts- floatation and Fenwick can technique.

UNIT II

Use and care of microscopes. Estimation of nematode population. Use of camera lucida for drawings and measurements. Methods of killing, fixing and preserving nematodes. Preparation of temporary and permanent mounts of nematodes. Microtomy.

UNIT III

Methods of raising pure culture of nematodes. Pathogenicity studies. Nematicide application and screening techniques. Screening crop varieties for resistance to nematodes.

Practical

Use and care of microscopes. Collection of soil and plant parts for nematode extraction by different methods. Extraction of cyst. Preparation of mounts. Staining of nematodes and infested plant tissues. Raising pure cultures of nematodes. Taking measurements of nematodes and drawing body parts. Experiments on pathogenicity. Nematicide and varietal screening against nematodes. Use of microtome.

Suggested Readings

Jonathan, E.I., Kumar, S., Devrajan, K. and Rajendran, G. 2001. Fundamentals of Plant Nematology. Devi publications, Tamil Nadu. 232p.

Luc, M., Sikora, R.A. and Brdige, J. (Ed.) 1990. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. Cambrian Printers Ltd. Paris. 629p.

Reddy, P.P. 1983. Plant Nematology. Pratibha Printing Press, Sudarshan Park, NewDelhi.287p.
Southey, J.F. 1970. Laboratory methods for work with plant and soil nematodes. Her majesty's stationery office, London.

22. ENT 522 NEMATODE PESTS OF AGRICULTURAL CROPS AND THEIR MANAGEMENT 1+1

Objective
To impart knowledge on important plant parasitic nematodes, their pathogenicity, host parasite relationship and integrated management.

Theory
UNIT I
Importance of plant parasitic nematodes. Methods of investigations of diseases caused by nematodes. Plant nematode relationships.
UNIT II
Concepts of pathogenicity. Host parasite relationship. Symptoms of nematode injury to plants. Histopathology of nematode infested tissues. Association of nematodes with other micro organisms and disease complexes.
UNIT III
Effect of environment on disease development. Detailed account of diseases caused by important plant parasitic nematodes on crops and their management.

Practical
Identification of symptoms caused by nematodes on different crops. Studies on nature and extent of damage done in the field on selected crops.

Suggested Readings
Jonathan, E.I., Cannayane, I., Devrajan, K., Kumar, S. and Ramakrishnan, S. 2005. Agricultural Nematology. Sri Sakthi Promotional Litho Process, Tamil Nadu. 260p.
Jonathan, E.I., Kumar, S., Devrajan, K. and Rajendran, G. 2001. Fundamentals of Plant Nematology. Devi publications, Tamil Nadu. 232p.
Luc, M., Sikora, R.A. and Brdige, J. (Ed.) 1990. Plant parasitic Nematodes in Subtropical and Tropical Agriculture. Cambrian Printers Ltd. Paris. 629p.
Reddy, P.P. 1983. Plant Nematology. Pratibha Printing Press, Sudarshan Park, NewDelhi. 287p.
Saxena, S.K., Khan, W., Rashid, A. and Khan, R.M. 1990. Progress in Plant Nematology. Nazia Printers, Lal Kun, Delhi. 616p.

23. ENT 523 BIOTECHNOLOGY IN NEMATODE MANAGEMENT 1+1

Objective
To familiarize the students with advanced techniques in the study of nematodes, and biotechnological tools in nematode management.

Theory
UNIT I
Cell biology – functional aspects of cell micro organelles - cell division – chromosomes, nucleic acids – protein synthesis – gene – gene expression. Model physiology of nematodes – *Cnenorhabditis elegans*.
UNIT II
Nematode genetics – receptors – biochemical basis of communication, plant nematode interaction, survival strategies – serology . Molecular mechanism of host resistance

against plant parasitic nematodes – histopathological cellular and molecular changes in the host feeding cells, cryptobiosis, biofumigation methods.

UNIT III

Biotechnological tools in nematode management. Entomopathogenic nematodes – scope and strategies in nematode management.

Practical

Isolation and quantification of protein from nematode juveniles and eggs. Enzyme polymorphism in root – knot nematode. Nematode DNA isolation from juveniles and eggs. Identification of resistance mechanism in plants. Mass production of EPN. Nematode free extraction of different bacteria.

Suggested Readings

Lamberti, F., Georgi, C. De and Bird D, Mck 1 994. Advances in Molecular Plant Nematology. NATO ASI series, Series A life sciences. Vol. 268 Plenum Press, NewYork, USA

Luc, M., Sikora, R.A. and Brdige, J. (Ed.) 1990. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. Cambrian Printers Ltd. Paris. 629p.

Saxena, S.K., Khan, W., Rashid, A. and Khan, R.M. 1990. Progress in Plant Nematology. Nazia Printers, Lal Kun, Delhi. 616p.

Sithanantham, S., David, B. V. and Selvaraj, P. 2005. Biotechnological Management of Nematode Pests and scope of Entomopathogenic Nematodes. Sun Agro Biotech Research Centre, Chennai. 185p.

24. ENT 524 INTRODUCTORY AND ECONOMIC ENTOMOLOGY 1+1

Objective :

To familiarize the students with systematic, morphology, economic importance and management of pests affecting various crops.

Theory

UNIT I

Introduction – position of insects in animal kingdom(Phylum, Order, Class). External morphology – shape, brief description of integument and different body regions – head, thorax and abdomen.

UNIT II

Economic classification of insects – reasons for dominance of insects, types of damage caused by insects (direct and indirect), brief description of different types of mouthparts. Pests of crop plants – common name, scientific name,brief description of stages and damage caused and control of important pests of – rice, coconut, vegetables (cucurbits, bhindi, chilli, brinjal, tomato and amaranthus), fruits – (banana and mango), spices – (Pepper), storage pests of rice and pulses.

UNIT III

Principles of insect contrl – introduction to natural and applied, prophylactic and curative, cultural, biological and chemical control, types of insecticides, newer approaches in pest control. Integrated pest management (IPM).

UNIT IV

Introduction to non – insect pests and their control (mites, nematodes, molluscus and rodents). Machineries for pest control

Practical

Types of insects – collection and preservation. Acquaintance with types of damages caused by insects. Acquaintance with crop pests of rice, coconut, vegetables (cucurbits,bhindi, chilli, brinjal, tomato and amaranthus), fruits (banana and mango),

spices (pepper), storage pests of rice and pulses. Acquaintance with non – insect pests. Familiarization with insecticides and plant protection with non- insect pests.

Suggested readings

David, B.V. 2001. Elements of Economic Entomology. Popular Book Depot, Madras, 536p.

Metcalf . L. C and Flint. W. P. 1973. Destructive and Useful Insects. Tata Mc Graw Hill, New Delhi.

Nair, M.R.G.K. 1986. Insects and Mites of Crops in India. Indian Council of Agricultural Research, New Delhi, 267 p.

Nair, M. R. G. K . 1999. Monograph on Crop Pests of Kerala and their Management. Kerala Agricultural University. 227.p

Srivastava, K. P. 2003. A text book of Applied Entomology. Vol. II. Kalyani Publishers, Ludhiana, pp. 497.

Ph.D COURSES

1. ENT 601 ADVANCED INSECT SYSTEMATICS 1+2

Objective

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. International Code of Zoological Nomenclature. Ethics and procedure for taxonomic publications.

Theory

UNIT I

Detailed study of three schools of classification- numerical, evolutionary and cladistics. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts and speciation processes and evidences. Zoogeography.

UNIT II

Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

UNIT III

Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN- Ethics.

UNIT IV

Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications - small publications of species descriptions, revisionary works, monographs, check lists, faunal volumes, etc.

Websites related to insect taxonomy anddatabases. Molecular Taxonomy, barcoding species.

Practical

Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, construction of taxonomic keys for the selected group. Development of descriptions, photographing, writing diagrams, and preparation of specimens for "type like" preservation. Submission of the collections made of the group. Multivariate Analysis techniques for clustering specimens into different taxa, and development of phenograms. Rooting and character polarisation for developing cladograms and use of computer programmes to develop cladograms.

Suggested Readings

CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers.* 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press,Ithaca.

Dakeshott J & Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology.* Springer-Verlag, Berlin.

Freeman S & Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Hennig W. 1960. *Phylogenetic Systematics*. Urbana Univ. Illinois Press, USA.

Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.

Mayr E & Ashlock PD. 1991. *Principles of Systematic Zoology.* 2nd Ed. McGraw Hill, New York.

Mayr E.1969. *Principles of Systematic Zoology*. McGraw-Hill, New York.

Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy.* Blackie Academic and Professional, London.

Ross HH. 1974. *Biological Systematics.* Addison Wesley Publ. Co., London.

Wiley EO. 1981. *Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists*. Columbia Univ. Press, USA.

2. ENT 602 IMMATURE STAGES OF INSECTS 1+1

Objective

To impart knowledge on morphology of immature stages of different groups of insects. Train students in identification of common pest species during their immature stages.

Theory

UNIT I

Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects.

UNIT II

Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

Types of immature stages; their collection, rearing and preservation. Identification of immature insects to orders and families, in endopterygote orders viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key.

Suggested Readings

Chu HF. 1992. *How to Know Immature Insects*. William Brown Publ., Iowa.
Peterson A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.
Stehr FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publ., Iowa.

3. ENT 603 ADVANCED INSECT PHYSIOLOGY 2+0

Objective

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones etc.

Theory

UNIT I

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, types of sclerotization.

UNIT II

Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.

UNIT III

Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

UNIT IV

Endocrine system and insect hormones, physiology of insect growth and development-metamorphosis, polyphenism and diapause. Energetics of muscle contractions.

Suggested Readings

Kerkut GA & Gilbert LI. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.

Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Assoc. for Advancement of Entomology, Trivandrum, Kerala.

4. ENT 604 ADVANCED INSECT ECOLOGY 1+1

Objective

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics.

Theory

UNIT I

Characterisation of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

UNIT II

Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of Associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of Insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites. Host seeking behaviour of parasitoids. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses.

UNIT III

Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

UNIT IV

Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies-timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

Practical

Methods of data collection under field conditions. Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc. Calculation of sample sizes by different methods. Fitting Poisson and Negative Binomial distributions and working out the data transformation methods. Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies - Calculation of changes under selection, Demonstration of genetic drift. Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/*Goniozus*/Female Bruchids etc.- A test of reproductive effort and fitness.

Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution. Exercises in development of Algorithms for crop modeling.

Suggested Readings

Barbosa P & Letourneau DK. (Eds.). 1988. *Novel Aspects of Insect-Plant Interactions*. Wiley, London.

Elizabeth BA & Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects.* Chapman & Hall, New York.

Freeman S & Herron JC.1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Gotelli NJ & Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.

Krebs C. 1998. *Ecological Methodology.* 2nd Ed. Benjamin-Cummings Publ. Co., New York.

Krebs CJ. 2001 *Ecology: The Experimental Analysis of Distribution and Abundance*. 5th Ed. Benjamin-Cummings Publ. Co., New York.

Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton University Press, Princeton.

Real LA & Brown JH. (Eds.). 1991. *Foundations of Ecology: Classic Papers with Commentaries.* University of Chicago Press, USA.

Southwood TRE & Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Wiley Blackwell, London.

Strong DR, Lawton JH & Southwood R. 1984. *Insects on Plants: Community Patterns and Mechanism*. Harward University Press, Harward.

Wratten SD & Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold Publ., London.

5. ENT 605 INSECT BEHAVIOUR 1+1

Objective

To acquaint the students with a thorough understanding of how natural selection has led to various survival strategies manifested as behaviour in insects.

Theory

UNIT I

Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behaviour, inducted behaviour, learnt behaviour and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism.

UNIT II

Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

UNIT III

Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour-kin selection, parental manipulation and mutualism; Selforganization and insect behaviour.

UNIT IV

Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behaviour, pollination behaviour, coevolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio- chemicals, auditory stimuli and visual signals in pest management.

Practical

Quantitative methods in sampling behaviour; training bees to artificial feeders; sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees. Evaluation of different types of traps against fruit flies with respect to signals; Use of honey bees/*Helicoverpa armigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

Suggested Readings

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford & IBH, New Delhi.

Awasthi VB. 2001. *Principles of Insect Behaviour*. Scientific Publ., Jodhpur.

Bernays EA & Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman & Hall, London.

Brown LB. 1999. *The Experimental Analysis of Insect Behaviour.* Springer, Berlin.

Krebs JR & Davies NB. 1993. *An Introduction to Behavioural Ecology.* 3rd Ed. Chapman & Hall, London.

Manning A & Dawkins MS. 1992. *An Introduction to Animal Behaviour*. Cambridge University Press, USA.

Mathews RW & Mathews JR. 1978. *Insect Behaviour.* A Wiley- InterScience Publ. John Wiley & Sons, New York.

6. ENT 606 RECENT TRENDS IN BIOLOGICAL CONTROL 1+1

Objective

To appraise the students with advanced techniques in handling of different bioagents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.

Theory

UNIT I

Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents *vis-à-vis* target pest populations.

UNIT II

Mass culturing techniques, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

UNIT III

Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of biocontrol agents, bankable project preparation.

UNIT IV

Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of biocontrol agents.

Practical

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various biocontrol agents, performance of efficiency analyses on target pests; project document preparation for establishing a viable mass-production unit /insectary.

Suggested Readings

Burges HD & Hussey NW. (Eds.). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.

Coppel HC & James WM. 1977. *Biological Insect Pest Suppression.* Springer Verlag, Berlin.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman & Hall, London.

Dhaliwal, GS & Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publ., New Delhi.

Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman & Hall, New York.

Huffakar CB & Messenger PS. 1976. *Theory and Practices of Biological Control.* Academic Press, London.

7. ENT 607 ADVANCED INSECTICIDE TOXICOLOGY 2+1

Objective

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

Theory

UNIT I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides.

UNIT II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

UNIT III

Joint action of insecticides; activation, synergism and potentiation.

UNIT IV

Problems associated with pesticide use in agriculture: pesticide resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

UNIT V

Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; insecticide laws and standards, and good agricultural practices.

Practical

Sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects.

Suggested Readings

Busvine JR. 1971. *A Critical Review on the Techniques for Testing Insecticides.* CABI, London.

Brooks. G.T and Roberts, T.R (Ed) 1999. Pesticide Chemistry and Biosciences. In *Food Environment challenge*. Royal society of Chemistry. UK

Das. K.G. 1981. *Pesticide Analysis.* New York Marcel Dekker Inc. New York.

Dhaliwal GS & Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publ., New Delhi.

Hayes WJ & Laws ER. 1991. *Handbook of Pesticide Toxicology.* Academic Press, New York.

Hayes A.W and Tailor Fraus, (Eds) 2001. Principles and Methods of Toxicology, Philadelphia.

Ishaaya I & Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action.* Narosa Publ. House, New Delhi.

Matsumura F. 1985. *Toxicology of Insecticides.* Plenum Press, New York.

Mayer M.S and Mc Laughlin J.R 1990. Insect pheromones and sex attractants CRC press, Boca Rato.

O' Brien RD. 1974. *Insecticides Action and Metabolism.* Academic Press, New York.

Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. *Insecticides in Agriculture and Environment.* Narosa Publ. House, New Delhi.

Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publ., New York.

8. ENT 608 ADVANCED HOST PLANT RESISTANCE 1+1

Objective

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

Theory

UNIT I

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species -gene pool; insect sources – behaviour in relation to host plant factors.

UNIT II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenoloxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

UNIT III

Breeding methods for insect resistance. Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

UNIT IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

Practical

Understanding mechanisms of resistance for orientation, feeding, oviposition *etc*., allelochemical bases of insect resistance; macroculturing of test insects like aphids, leaf/plant hoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

Suggested Readings

Panda N. 1979. *Principles of Host Plant Resistance to Insects*. Allenheld, Osum & Co., New York.

Rosenthal GA & Janzen DH. (Eds.). 1979. *Herbivores – their Interactions with Secondary Plant Metabolites*. Vol. I, II. Academic Press, New York.

Sadasivam S & Thayumanavan B. 2003. *Molecular Host Plant Resistance to Pests*. Marcel Dekker, New York.

Smith CM, Khan ZR & Pathak MD. 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*. CRC Press, Boca Raton, Florida.

9. ENT 609 ADVANCED ACAROLOGY 1+1

Objective

To acquire a good working knowledge of identification of economically important groups of mites up to the species level, a detailed understanding of the newer acaricide molecules and utilization of predators.

Theory

UNIT I

Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnidae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

UNIT II

Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

UNIT III

Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

UNIT IV

Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi- identification, isolation and utilization.

Practical

Identification of commonly occurring mites up to species, preparation of keys for identification. Collection of specific groups of mites and preparing their identification keys. Rearing phytoseiid mites and studying their role in suppression of spider mites. Management of mite pests of crops using acaricides, phytoseiid predators, fungal pathogens *etc.*

Suggested Readings

Evans GO.1992. *Principles of Acarology.* CABI, London.

Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents- An Illustrated Key and Manual*. Chapman & Hall, New York.

Gupta SK. 1985. *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta.
Krantz GW. 1970. *A Manual of Acarology.* Oregon State University Book Stores, Corvallis, Oregon.
Sadana GL. 1997. *False Spider Mites Infesting Crops in India.* Kalyani Publ. House, New Delhi.

10. ENT 610 AGRICULTURAL ORNITHOLOGY 1+1

Objective
To expose the students to the prevalence of birds in agricultural fields, their habitat associations and the beneficial and harmful role played by birds in crop fields and management of pest situations.

Theory
UNIT I
Status of agricultural ornithology in India, groups of birds associated with agro-ecosystems. Habitat associations of birds in both wet and dry agricultural systems. Association of birds with different cultivation practices and crop stages, their seasonality and succession. Pestiferous and beneficial birds associated with different crops, their general biology and ecology. Food and feeding habits of birds in crop fields.
UNIT II
Nature of damage caused by birds in different crops. Foraging ecology of birds in agricultural fields. Birds affecting stored grains in houses and godowns. Beneficial role of birds in agriculture and attracting them to field. Use of bird excreta in agriculture. Management of bird pests in agriculture: physical, cultural, ecological and chemical methods.
Practical
Study of different groups of birds associated with agriculture, their morphology and field identification. Field visits to different agroecosystems. Study of bird associations with different crop stages. Study of nesting and roosting habits of birds in agricultural habitats. Study of the feeding habits, nature and types of damage caused by birds in selected crops. Visits to godowns. Analysis and study of the use of bird excreta in agriculture at a bird sanctuary. Field visits to paddy growing command areas to study birds in crop fields. Assignments on assessing bird damage, estimation of populations etc.
Suggested Readings
Dhindsa SR & Parasharya BM. 1998. *Birds in Agricultural Ecosystem.* Society for Applied Ornithology, Hyderabad.
Mehrotra KN & Bhatnagar RK. 1979. *Status of Economic Ornithology in India- Bird Depredents, Depredations and their Management.* ICAR, New Delhi.
Vasudeva Rao & Dubey OP. 2006. Grainivorous Pests and their Management. In: *Vertebrate Pests in Agriculture, The Indian Scenario* (Ed: Sridhara, S.), Scientific Publ., Jodhpur.

11. ENT 611 MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH 1+1

Objective

To familiarize the students with DNA recombinant technology, marker genes, transgenic plants, biotechnology in sericulture and apiculture.

Theory

UNIT I

Introduction to molecular biology; techniques used in molecular biology.

UNIT II

DNA and RNA structure in insects- transcription and translation mechanisms. Recombinant DNA technology, identification of genes/nucleotide sequences for characters of interest.

UNIT III

Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, chitinase, CPTI; lectins and proteases. Bt toxin.

UNIT IV

Insect gene transformation; Genetic improvement of natural enemies Genetic engineering of entomopathogens, baculoviruses, Bt. and entomopathogenic fungi.Transgenic plants for pest resistance. Resistance management strategies in transgenic crops.

UNIT V

Insect immune systems in comparison to vertebrates. DNA-based diagnostics DNA fingerprinting for taxonomy and phylogeny. Molecular basis of metamorphosis.

Practical

Isolation of DNA/RNA; purity determinations; base pair estimation; agarose gel electrophoresis; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

Suggested Readings

Bhattacharya TK, Kumar P & Sharma A. 2007. *Animal Biotehnology*. 1st Ed., Kalyani Publ., New Delhi.

Hagedon HH, Hilderbrand JG, Kidwell MG & Law JH. 1990. *Molecular Insect Science*. Plenum Press, New York.

Oakeshott J & Whitten MA.. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.

Rechcigl JE & Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests.* Lewis Publ., North Carolina.

Roy U & Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publ., New Delhi.

Singh BD. 2008. *Biotechnology (Expanding Horizons)*. Kalyani Publ., New Delhi.

Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publ., New Delhi.

12. ENT 612 ADVANCED INTEGRATED PEST MANAGEMENT 2+0

Objective

To acquaint the students with recent concepts of integrated pest management. Surviellance and data base management. Successful national and international case histories of integrated pest management, non conventional tools in pest management.

Theory

UNIT I

Principles of sampling and surveillance; database management and computer programming, simulation techniques and system analysis and modeling.

UNIT II

Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests.

UNIT III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes. Application of IPM to farmers' realtime situations.

UNIT IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

Suggested Readings

Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches.* Kalyani Publ., New Delhi.

Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.

Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management.* Springer, Berlin.

Koul O & Cuperus GW. 2007. *Ecologically Based Integrated PestManagement.* CABI, London.

Koul O, Dhaliwal GS & Curperus GW. 2004. *Integrated Pest Management -Potential, Constraints and Challenges.* CABI, London.

Maredia KM, Dakouo D & Mota-Sanchez D. 2003. *Integrated Pest Management in the Global Arena.* CABI, London.

Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management.* John Wiley & Sons, New York.

Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concept in Integrated Pest Management.* Prentice Hall, New Delhi.

Oakeshott J & Whitten MA.. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.

Pedigo RL. 1996. *Entomology and Pest Management.* Prentice Hall, New Delhi.

Rechcigl JE & Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests.* Lewis Publ., North Carolina.

Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.* Marcel Dekker, New York.

13. ENT 613 PLANT BIOSECURITY AND BIOSAFETY 2+0

Objective

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

Theory

UNIT I

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases.

UNIT II

National Regulatory Mechanism and International Agreements/ Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), Biological diversity Act 2002 International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

UNIT III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Suggested Readings

FAO Biosecurity Toolkit 2008. www.fao.org/docrep/010/a1140e/a1140e00.htm
Laboratory Biosecurity Guidance.
http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_EPR_2006.pdf
Grotto Andrew J & Jonathan B Tucker. 2006. *Biosecurity: A Comprehensive Action Plan.*
http://www.americanprogress.org/kf/biosecurity_a_comprehensive_action_plan.pdf
Biosecurity Australia. www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia
Biosecurity New Zealand. www.biosecurity.govt.nz
DEFRA.www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
Randhawa GJ, Khetarpal RK, Tyagi RK & Dhillon. BS (Eds.). 2001.
Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.
Khetarpal RK & Kavita Gupta 2006. *Plant Biosecurity in India - Status and Strategy*. Asian Biotechnology and Development Review 9(2): 39-
Biosecurity for Agriculture and Food Production. http://www.fao.org/biosecurity/
CFIA.http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht Ml

14. ENT 614 NEMATODE MORPHOLOGY AND TAXONOMY 2+1

Objective

To aquaint the students with morphology and anatomy of nematode, different systems of classification and methods of identification.

Theory

UNIT I

Morphology, anatomy, histology and physiology of various systems of nematodes. Reproduction and development of nematodes including gametogenesis, embryonic development, hatching, moulting etc.

UNIT II

Classification of nematodes-different systems of classification, important characters for identification upto genera with special reference to plant parasitic forms.

UNIT III

Identification of nematodes with the help of keys and descriptions. PCR methods and RFLP methods in identification.

Practical

Studies on the morphological and anatomical structures of different plant parasitic nematodes. Preparation of permanent mounts of plant parasitic nematodes. Measurements of nematodes. Micrometry and use of camera lucida for drawings.

Suggested Readings

Jonathan, E.I., Cannayane, I., Devrajan, K., Kumar, S. and Ramakrishnan, S. 2005. Agricultural Nematology. Sri Sakthi Promotional Litho Process, Tamil Nadu. 260p.

Jonathan, E.I., Kumar, S., Devrajan, K. and Rajendran, G. 2001. Fundamentals of Plant Nematology, Devi publications, Tamil Nadu. 232p

Luc, M., Sikora, R.A. and Bridge, J. (Ed.). 1990. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. Cambrian Printers Ltd., Paris. 629p.

Reddy, P.P. 1983. Plant Nematology. Pratibha Printing Press, Sudarshan Park, New Delhi, 287p.

Saxena, S.K., Khan, W., Rashid, A. and Khan, R.M. 1990. Progress in Plant Nematology. Nazia Printers, Lal Kun, Delhi.260.p

15. ENT 615 NEMATODE ECOLOGY AND CONTROL 2+1.

Objective

To familiarize students with factors governing the distribution and abundanceof nematodes and methods to manage them

Theory

UNIT I

Ecological classification, prevalence and distribution of nematodes. Soil as an environment for nematodes. Effect of soil factors like soil structure, soil type, pore size, soil moisture, aeration temperature, osmotic pressure, light, pH etc. on nematode survival.

UNIT II

Effect of biological factors like host plant physiology. Organic matter and soil micro organisms on nematode population fluctuation. Ecological relationship with parasites, predators and other micro organisms. Nematode behaviour in relation to biotic and abiotic factors.

UNIT III

Methods of nematode control – chemical - biochemistry and mode of action of nematicides, application of nematicides, advantages and disadvantages. Physical, mechanical, cultural, regulatory and biological methods of nematode control. Plant resistance to nematodes and breeding for resistance.

Practical

Studies on nematode groups in different crop ecosystems. Determination of population changes and community structure in different crops. Experiments on influence of soil factors like soil temperature, soil moisture, pH etc. on nematode activity. Methods of application of nematicides – Determination of the thermal death point of parasitic nematodes. Estimation of efficacy of nematicides.

Suggested Readings

Reddy, P.P. 1983. Plant Nematology. Pratibha Printing Press, Sudarshan Park, New Delhi.

Saxena, S.K., Khan, W., Rashid, A. and Khan, R.M. 1990. Progress in Plant Nematology. Nazia Printers, Lal Kun, Delhi. 260.p

List of Journals

 Agricultural and Forest Entomology- Royal Entomological Society, UK
 Annual Review of Entomology- Paloatto, California, USA
 Applied Soil Ecology- Elsevier Science, Amsterdam, The Netherlands
 Biopesticides International- Koul Research Foundation, Jalandhar
 Bulletin of Entomological Research- CAB International, Wallingford, UK
 Bulletin of Grain Technology- Food Grain Technologist Res. Association of India, Hapur
 Crop Protection- Elsevier's Science, USA
 Ecological Entomology -Royal Entomological Society, UK
 Entomologia Experimentalis Applicata- Kluwer Academic Publishers, The Netherlands
 Entomon- Association for Advancement of Entomology, Kerala
 Environmental Entomology- Entomological Society of America, Maryland, USA
 Indian Journal of Applied Entomology- Entomological Research Association, Udaipur
 Indian Journal of Entomology- Entomological Society of India, New Delhi
 Indian Journal of Plant Protection- Plant Protection Society of India, Hyderabad
 Indian Journal of Sericulture- Central Silk Board, Bangalore
 International Journal of Acarology- Indira Acarology Publishing House, Minessota, USA
 International Journal of Pest Management- Taylor and Francis, UK
 Journal of Acarology- Acarological Society of India, UAS, Bangalore
 Journal of Apiculture Research- IBRA, UK
 Journal of Applied Entomology- Blackwell Science Ltd., Oxford, UK
 Journal of Biocontrol- Society for Biocontrol Advancement, Bangalore
 Journal of Economic Entomology- Entomological Society of America, Maryland, USA
 Journal of Entomological Research- Malhotra Publishing House, New Delhi
 Journal of Insect Behaviour- Plenum Publishing Corporation, NY, USA
 Journal of Insect Physiology- Pergamon Press, UK
 Journal of Insect Science- Indian Society for the Advancement of Insect Science, Ludhiana
 Journal of Invertebrate Pathology, Elsevier Publ. Corporation, The Netherlands
 Journal of Soil Biology and Ecology, Indian Society of Soil Biology and Ecology, UAS, Bangalore
 Journal of Stored Products Research- Elsevier's Science, USA
 Pesticides Research Journal- Society of Pesticides Science, New Delhi
 Pesticide Science – Oxford, London
 Pesticide Biochemistry and Physiology- New York, USA
 Physiological Entomology- Royal Entomological Society, UK
 Review of Applied Entomology- CAB International, Wallingford, UK
 Systematic Entomology- Royal Entomological Society, UK

e-Resources

- http://www.colostate.edu/Depts/Entomology/
- http://www.ent.iastate.edu/list/
- http://www.biologybrowser.org/
- http://www.teachers.ash.org.au/aussieed/insects.htm
- http://entomology.si.edu/
- http://www.intute.ac.uk/healthandlifesciences/agriculture/
- http://www.agriculture.gov.au/
- http://www.gbif.org/
- http://www.mosquito.org/
- http://www.nysaes.cornell.edu/fst/faculty/acree/pheronet/index.html
- http://medent.usyd.edu.au/links/links.htm
- http://www.ent.iastate.edu/list/
- http://www.ento.csiro.au/index.html
- http://www.biocollections.org/lib/listbycat.php?cat=Entomology
- http://www.IPMnet.org/DIR/
- http://www.nhm.ac.uk/hosted_sites/acarology/
- http://www.agnic.org/
- http://ars-genome.cornell.edu/
- http://www.tulane.edu/~dmsander/garryfavweb.html
- http://www.ufsia.ac.be/Arachnology/Arachnology.html
- http://www.ippc.orst.edu/IPMdefinitions/home.html
- http://www.ent.iastate.edu/list/
- http://www.ippc.orst.edu/cicp/pests/vertpest.htm
- http://ipmwww.ncsu.edu/cicp/IPMnet_NEWS/archives.html
- http://nematode.unl.edu/wormsite.htm
- http://www.bmckay.com/
- http://ace.ace.orst.edu/info/extoxnet/pips/pips.html
- http://www.ifgb.uni-hannover.de/extern/ppigb/ppigb.htm
- http://www.ceris.purdue.edu/npirs/npirs.html
- http://www.ces.ncsu.edu/depts/pp/bluemold/
- http://www.ipm.ucdavis.edu
- http://ippc.orst.edu/pestalert/
- http://www.orst.edu/Dept/IPPC/wea/
- http://www.barc.usda.gov/psi/bpdl/bpdl.html
- http://www.nalusda.gov/bic/BTTOX/bttoxin.htm
- http://www.nysaes.cornell.edu/ent/biocontrol/
- http://entweb.clemson.edu/cuentres/
- http://www.agr.gov.sk.ca/Docs/crops/cropguide00.asp
- http://www.caf.wvu.edu/kearneysville/wvufarm6.html
- http://www.chebucto.ns.ca/Environment/NHR/lepidoptera.html
- http://nt.ars-grin.gov/fungaldatabases/databaseframe.cfm
- http://www.orst.edu/dept/infonet/
- http://www.attra.org/attra-pub/fruitover.html
- http://www.ceris.purdue.edu/napis/pests/index.html
- http://danpatch.ecn.purdue.edu/~epados/farmstead/pest/src/
- http://ipmwww.ncsu.edu/current_ipm/otimages.html
- http://nematode.unl.edu/wormhome.htm
- http://www.ipm.ucdavis.edu/
- http://hammock.ifas.ufl.edu/en/en.html
- http://www.rce.rutgers.edu/weeddocuments/index.htm
- http://www.agric.wa.gov.au/ento/allied1.htm
- http://biology.anu.edu.au/Groups/MES/vide/refs.htm
- http://chrom.tutms.tut.ac.jp/JINNO/PESDATA/00database.html
- http://agrolink.moa.my/doa/english/croptech/crop.html

 http://nbo.icipe.org/agriculture/stemborers/default.html
 http://www.bdt.org.br
 http://www.bspp.org.uk/fbpp.htm
 http://www.elsevier.com/inca/publications/store/3/5/6/
 http://www.hbz-nrw.de/elsevier/00207322/
 http://ianrhome.uni.edu/distanceEd/entomology/401_801_insectphysio.shtml
 www.entsoc.org
 http://aprtc.org/
 http://www.ipmnet.org/news.html
 http://www.pestnet.org/
 www.fruitfly.org
 www.celera.com
 www.hgsc.bcm.tmc.edu/drosophila
 http://sdb.bio.purdue.edu/fly/aimain/links
 http://flybase.bio.indiana.edu/
 http://naasindia.org/journals.htm

Suggested Broad Topics for Master's and Doctoral Research

 Strengthening of eco-friendly strategies of integrated insect and mite pest management including:
    - Biological control
    - Bio-rational pesticides
    - Host plant resistance
    - Transgenic crop protection
    - Judicious use of pesticides
    - Molecular biosystematics
 Investigations on ecological factors including:
    - Survey and surveillance of insect and mite pests
    - Forecasting of insect and mite pest population life-tables and predictive models
    - Insect and mite biology
    - Population dynamics as influenced by abiotic and biotic factors
 Studies on role of pollination including honeybees in increasing crop yields and production of honey and other allied products and management of honeybee diseases and mites
 Pesticide resistance and Insecticide Resistance Management strategies
 Biotypes of pests
 Below ground biodiversity- Bio-indicator of soil health, role in decomposition of litter, soil physico-chemical properties
 Bioprospecting for protocols, peptides, genes, insecticidal proteins and antibiotics
 Climate change and pests
 IPM in protected cultivation
 Location specific IPM strategies in different cropping systems
 Genetic improvement of natural enemies
 Genetic improvement of silkworms
 Refinement of silkworm rearing technology for different regions
 Management of silkworm pests and diseases
 Crop-pest modeling
 Insect biochemistry- pheromones, hormones and neuropeptides
 Insect physiology- metabolism and regulatory mechanisms.
 Indigenous technology
 Plants as sources of insecticides
 Molecular systematics – finger printing of species
 Insect systematics and phylogeny

VI PLANT PATHOLOGY

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
PL PATH 501*	MYCOLOGY	2+1
PL PATH 502*	PLANT VIROLOGY	2+1
PL PATH 503*	PLANT BACTERIOLOGY	2+1
PL PATH 504*	PRINCIPLES OF PLANT PATHOLOGY	3+0
PL PATH 505*	DETECTION AND DIAGNOSIS OF PLANT DISEASES	0+2
PL PATH 506	PRINCIPLES OF PLANT DISEASE MANAGEMENT	2+1
PL PATH 507	DISEASES OF FIELD CROPS AND VEGETABLES	2+1
PL PATH 508	DISEASES OF FRUITS AND ORNAMENTAL CROPS	2+1
PL PATH 509	DISEASES OF PLANTATION CROPS, SPICES AND MEDICINAL PLANTS	2+1
PL PATH 510	SEED HEALTH TECHNOLOGY	2+1
PL PATH 511	CHEMICALS IN PLANT DISEASE MANAGEMENT	2+1
PL PATH 512	ECOLOGY AND MANAGEMENT OF SOIL-BORNE PLANT PATHOGENS	2+1
PL PATH 513	DISEASE RESISTANCE IN PLANTS	2+0
PL PATH 514	INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS	1+1
PL PATH 515	BIOLOGICAL CONTROL OF PLANT DISEASES	2+1
PL PATH 516	INTEGRATED DISEASE MANAGEMENT	2+1
PL PATH 517	MUSHROOM PRODUCTION TECHNOLOGY	2+1
PL PATH 518	EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES	2+1
PL PATH 519	POST HARVEST DISEASES	2+1
PL PATH 520	PLANT QUARANTINE	2+0
PL.PATH.521	EXTENSIOPN PLANT PATHOLOGY	**1+1**
PL PATH 591	MASTER'S SEMINAR	0+1
PL PATH 599	MASTER'S RESEARCH	20
	Ph.D Courses	
PL PATH 601	ADVANCED MYCOLOGY	2+1
PL PATH 602	ADVANCED VIROLOGY	2+1
PL PATH 603	ADVANCED BACTERIOLOGY	2+1
PL PATH 604**	MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION	2+1
PL PATH 605	PRINCIPLES AND PROCEDURES OF CERTIFICATION	0+1
PL PATH 691	DOCTORAL SEMINAR I	0+10
PL PATH 692	DOCTORAL SEMINAR II	0+1
PL PATH 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme;
** Compulsory for Ph. D. programme;
$ Cross-listed with Entomology

1.PL PATH 501 MYCOLOGY 2+1

Objective

To study the nomenclature, classification and characters of fungi.

Theory

UNIT I

Introduction, definition of different terms, basic concepts.

UNIT II

Importance of mycology in agriculture, relation of fungi to human affairs, history of mycology.

UNIT III

Concepts of nomenclature and classification, fungal biodiversity, reproduction in fungi.

UNIT IV

The comparative morphology, ultrastructure, characters of different groups of fungi up to generic level: (a) Myxomycota and (b) Eumycota- i)Mastigomycotina ii) Zygomycotina, iii) Ascomycotina, iv)Basidiomycotina, v) Deuteromycotina. Lichens types and importance,

fungal genetics and variability in fungi.

Practical

Detailed comparative study of different groups of fungi; collection, identification and preservation of specimens. Isolation and identification of plant pathogenic fungi.

Suggested Readings

Ainsworth GC, Sparrow FK & Susman HS. 1973. *The Fungi – An Advanced Treatise*. Vol. IV (A & B). Academic Press, New York.

Alexopoulos CJ, Mims CW & Blackwell M.2000. *Introductory Mycology.*5th Ed. John Wiley & Sons, New York.

Dube,H.C.2005.an Introduction to Fungi.Vikas Publishing House Pvt. Ltd.New Delhi

Mehrotra RS & Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.

Sarbhoy AK. 2000. *Text book of Mycology*. ICAR, New Delhi.

Singh RS. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.

Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press,Cambridge, New York.

2. PL PATH 502 PLANT VIROLOGY 2+1

Objective

To acquaint with the structure, virus-vector relationship, biology and management of plant viruses.

Theory

UNIT I

History of plant viruses, composition and structure of viruses.The origin and evolution of virus.

UNIT II

Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host virus interaction, virus vector relationship.

UNIT III

Virus nomenclature and classification, genome organization, replication and movement of viruses.

UNIT IV
Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics.
Bioassay of Plant Viruses and serological properties.
UNIT V
Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, virusoids, prions. Principles of the working of electron-microscope and ultra-microtome.
UNIT VI
Origin and evolution, mechanism of resistance, genetic engineering,ecology, and management of plant viruses.

Practical

Study of symptoms caused by viruses, transmission, assay of viruses,physical properties, purification, method of raising antisera, serological tests, electron microscopy and ultratomy, PCR.

Suggested Readings

Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.
Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ & Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI,Wallington.
Gibbs A & Harrison B. 1976. *Plant Virology - The Principles*. Edward Arnold, London.
Hull R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.
Noordam D. 1973. *Identification of Plant Viruses, Methods andExperiments*. Oxford & IBH, New Delhi.
Smith.K.M.(1972) A textbook of plant virus diseases.Longman Harlow.
Walkey, D.G.A. 1985. Applied Plant Virology. Heinemann, London

3. PL PATH 503 PLANT BACTERIOLOGY 2+1

Objective

To acquaint with plant pathogenic prokaryote (procarya) and theirstructure, nutritional requirements, survival and dissemination.

Theory

UNIT I
History and introduction to phytopathogenic procarya, viz., bacteria,phytoplasma, spiroplasmas and other fastidious vascular bacteria. Importance of phytopathogenic bacteria.
UNIT II
Evolution, classification and nomenclature of phytopathogenic procarya and important diseases caused by them.
UNIT III
Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya.
UNIT IV
General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios.
UNIT V
Procaryotic inhibitors and their mode of action against phytopathogenic bacteria.
UNIT VI
Survival and dissemination of phytopathogenic bacteria.68

Practical

Isolation, purification, identification and host inoculation of phytopathogenic bacteria, staining methods, biochemical and serological characterization, isolation of plasmid and use of antibacterial chemicals/antibiotics.

Suggested Readings

Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.

Jayaraman J & Verma JP. 2002. *Fundamentals of Plant Bacteriology*.Kalyani Publ., Ludhiana.

Mount MS & Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II.Academic Press, New York.

Verma JP, Varma A & Kumar D. (Eds). 1995. *Detection of PlantPathogens and their Management*. Angkor Publ., New Delhi.

Verma JP. 1998. *The Bacteria*. Malhotra Publ. House, New Delhi.

4.PL PATH 504 PRINCIPLES OF PLANT PATHOLOGY 3+0

Objective

To introduce the subject of Plant Pathology, its concepts and principles.

Theory

UNIT I

Importance, definitions and concepts of plant diseases, history and growthof plant pathology, biotic and abiotic causes of plant diseases.

UNIT II

Growth, reproduction, survival and dispersal of important plant pathogens,role of environment and host nutrition on disease development Epidemiology, yield loss assessment/phytopathometry.

UNIT III

Host parasite interaction, recognition concept and infection,symptomatology, disease development- role of enzymes, toxins, growthregulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PRproteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

UNIT IV

Genetics of resistance; 'R' genes; mechanism of genetic variation inpathogens; molecular basis for resistance; marker-assisted selection;genetic engineering for disease resistance,physiological specialization , races , parasexuality, saltation, adoption, mutation, hybridization.

UNIT V

Disease management strategies.

Suggested Readings

Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.

Heitefuss R & Williams PH. 1976. *Physiological Plant Pathology*. SpringerVerlag, Berlin, New York.

Mehrotra RS & Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi.

Singh RS. 2002. *Introduction to Principles of Plant Pathology*. Oxford &IBH, New Delhi.

Singh DP & Singh A. 2007. *Disease and Insect Resistance in Plants*. Oxford & IBH, New Delhi.

Upadhyay RK & Mukherjee KG. 1997. *Toxins in Plant Disease*
Development and Evolving Biotechnology. Oxford & IBH, New Delhi.

Vidhyasekaran, P.2004. Concise encyclopedia of Plant Pathology.Vikas Books Pvt.New Delhi

5.PL PATH 505 DETECTION AND DIAGNOSIS OF PLANT DISEASES 0+2

Objective

To impart training on various methods/techniques/instruments used in the study of plant diseases/pathogens.

Practical

UNIT I

Methods to prove Koch's postulates with biotroph and necrotroph pathogens, pure culture techniques, use of selective media to isolate pathogens.

UNIT II

Preservation of plant pathogens and disease specimens, use of haemocytometer, micrometer, centrifuge, pH meter, camera lucida.

UNIT III

Microscopic techniques and staining methods, fluorescent microscopy, phase contrast microscopy ,chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens.Evaluation of fungicides, bactericides etc.; field experiments, data collection and preparation of references.

Suggested Readings

Aneja,K.R.2003.Experiments in Microbiology,Plant Pathology and Biotechnology(4th edition)New Age International (P)Ltd.Publishers, New Delhi.

Baudoin ABAM, Hooper GR, Mathre DE & Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.

Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur

Dhingra OD & Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.

Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*. CABI Wallington.

Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.

Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.

Forster D & Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology*.Humana Press, Totowa, New Jersey.

Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press,Florida.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agic. Pub. Doc. Wageningen.

Trigiano RN, Windham MT & Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida.

Vishunavat,K.,Kolte,S.J.2005.Essentials of Phytopathological techniques, Kalyani Publishers,Noida

6.PL PATH 506 PRINCIPLES OF PLANT DISEASE MANAGEMENT 2+1

0bjectives

To acquaint with different strategies for management of plant diseases.

Theory

UNIT I

Principles of plant disease management – management through regulatory measures, cultural and biological methods of plant disease control.

UNIT II

Importance and history of chemical and botanical methods of plant disease anagement..Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures. Chemotherapy. Fungicide formulations. Mode of action of fungicides,antibiotics and antiviral chemicals, Fungicide resistance management.Integrated control measures of plant diseases. Disease resistance and molecular approach for disease management

UNIT III

Physical methods and integrated approaches in plant disease management.Disease resistance and breeding for resistant varieties.Immunisation , systemic acquired resistance and use of plant activators, Molecular approahes of disease management.

Practical

Proving Koch's postulates, Soil solarization**,** Preparation of botanicals and antiviral principles(AVP), Mass production of biocontrol agents, Familiarization with common fungicides, preparation and application, *In vitro* and *in vivo* evaluation of chemicals against plant pathogens; ED and MIC values, study of structural details of sprayers and dusters.

Suggested Readings

Arjunan,G.,Karthikeyan,G. and Dinakaran,D.2005. Applied Plant Pathology.Anbil Dharmalingam Agricultural College and Research Institute, T.N.A.U., Thiruchirappalli.

Chaube, H.S. and Pundhir, V.S.2005. Crop Diseases and their management. Prentice-Hall India, New Delhi.

Fry WE. 1982. *Principles of Plant Disease Management*. Academic Press, New York.

Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington.

Marsh RW. 1972. *Systemic Fungicides*. Longman, New York.

Nene YL & Thapliyal PN. 1993. *Fungicides in Plant Disease Control*.Oxford & IBH, New Delhi.

Palti J. 1981. *Cultural Practices and Infectious Crop Diseases*. Springer-Verlag, New York.

Singh, R.S.2001.Plant Disease Managemenet.Oxford and IBH Publishing House Co. Pvt. Ltd., New Delhi.

Vyas SC. 1993 *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

7. PL PATH 507 DISEASES OF FIELD CROPS AND VEGETABLES 2+1

Objective

To educate about the nature, prevalence, etiology, symptomatology factors affecting disease development and control measures of field and medicinal crop diseases and giving importance to the crops of Kerala.

Theory

UNIT I

Diseases of Cereal crops- wheat, oats, barley, rice, pearl millet, sorghum,maize, ragi and other minor millets.

UNIT II

Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

UNIT III

Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed,sunflower, groundnut, castor.

UNIT IV

Diseases of Cash crops- cotton, sugarcane and tobacco.

UNIT V

Diseases of Fodder legume crops- berseem and lucerne.

UNIT VI

Nature, prevalence, factors affecting disease development of bulb, leafy vegetables, bhindi, crucifers, cucurbits and solanaceaous vegetables. Diseases of protected cultivation.

UNIT VII

Symptoms and management of diseases of different root, bulb, leafy vegetables, bhindi,crucifers , cucurbits and solanaceaous vegetable crops.

Practical

Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops. Collection and dry preservation of diseased specimens of important crops.

Suggested Readings

Joshi LM, Singh DV & Srivastava KD. 1984. *Problems and Progress of Wheat Pathology in South Asia*. Malhotra Publ. House, New Delhi.

Peethambaran,C.K.,Girija,V.K.,Umamaheswaran,K. and Gokulapalan,C. 2008.Diseases of crop Plants and their Manangement.Kerala Agricultural University,Vellanikkara,

Prakasam,V.Valluvaparidasan,V.Reguchander,t.,Prabakar,K.,Thiruvudainambi,S.1997. Field Crop Diseases.A.E.Publication,Coimbatore

Rangaswami G. 1999. *Diseases of Crop Plants in India*. 4th Ed.. Prentice Hall of India, New Delhi.

Ricanel C, Egan BT, Gillaspie Jr AG & Hughes CG. 1989. *Diseases of Sugarcane, Major Diseases*. Academic Press, New York.

Singh RS. 1998. *Plant Diseases*. 7th Ed. Oxford & IBH, New Delhi.

Singh US, Mukhopadhyay AN, Kumar J & Chaube HS. 1992. *Plant Diseases of Internatiobnal Importance*. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

8.PL PATH 508 DISEASES OF FRUITS AND ORNAMENTAL CROPS 2+1

Objective

To acquaint with diseases of fruits, plantation, ornamental plants and their management.

Theory

UNIT I

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like banana, mango, citrus, papaya,pineapple, sapota, grapes, guava and management of the diseases.

UNIT II

Symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum,apricot, cherry, walnut, almond, strawberry, ber, , fig, pomegranate, date palm and management of the diseases.

UNIT III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as rose, jasmine, anthurium, orchids,heliconia, gladiolus, tulip, carnation,marigold, chrysanthemum.foliage plants and their management.

Practical

Detailed study of symptoms and host parasite relationship of representative diseases of the important fruit crops and ornamentals. Collection and dry preservation of diseased specimens of important crops.

Suggested Readings

Chattopadyay,S.B. and Maity,S.1990.Diseases of betelvine and spices.ICAR,New Delhi.

Gupta VK &.Sharma SK. 2000. *Diseases of Fruit Crops*. Kalyani Publ.,New Delhi.

Peethambaran,C.K.,Girija,V.K.,Umamaheswaran,K.andGokulapalan,C.2008. Diseases of Crop Plants and their Manangement.Kerala Agricultural University,Vellanikkara

Pathak VN. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Santha Kumari,P.(ed.)2004.Advances in the diseases of Plantation crops and spices.IDB Co. Lucknow

Singh RS. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Walker JC. 2004. *Diseases of Vegetable Crops*. TTPP, India.

9.PL PATH 509 DISEASES OF PLANTATION CROPS, SPICES AND MEDICINAL PLANTS 2+1

Objective

To impart knowledge about symptoms, epidemiology of different diseases of plantation crops, spices and medicinal plants and their management.

Theory

UNIT I

Symptoms, mode of perpetuation of diseases of plantation crops such as coconut, arecanut, oilpalm, cashew, cocoa, tea, coffee, rubber and their management.

UNIT II

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, ,cardamom ginger betelvine, saffron, cumin, coriander, turmeric, fennel, fenugreek, tree spices, and vanilla

UNIT III

Medicinal crops- plantago, liquorice, *mulathi,* rosagrass, sacred basil,mentha, *ashwagandha, Aloe vera,* thippali,kachalom and Adathoda

Practical

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

Suggested Readings

Chaube HS, Singh US, Mukhopadhyay AN & Kumar J. 1992. *Plant Diseases of International Importance*. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs,

New Jersey.

Gupta VK & Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publ.,New Delhi

Sherf AF & Mcnab AA. 1986. *Vegetable Diseases and their Control*.Wiley InterScience, Columbia.
Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.
Gupta SK & Thind TS. 2006. *Disease Problem in Vegetable Production*.Scientific Publ., Jodhpur.
Sohi,H.S.1992.Diseases of ornamental plants in India.ICAR,New Delhi.
Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

10.PL PATH 510 SEED HEALTH TECHNOLOGY 2+1

Objective
To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/loses and management.

Theory
UNIT I
History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.
UNIT II
Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.
UNIT III
Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.
UNIT IV
Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism.

Practical
Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Relationship between seed-borne infection and expression of the disease in the field.

Suggested Readings
Agarwal VK & JB Sinclair. 1993. *Principles of Seed Pathology*. Vols. I & II, CBS Publ., New Delhi.
Hutchins JD & Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, Wallington.
Maude,R.B.1995. Seedborne diseases and their control. Horticultural Research International.Wellsbourne, U.K.
Paul Neergaard. 1988. *Seed Pathology*. MacMillan, London.
Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

11.PL PATH 511 CHEMICALS IN PLANT DISEASE MANAGEMENT 2+1

Objective
To impart knowledge on the concepts, principles and judicious use of chemicals in plant disease management.

Theory

UNIT I

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals.

UNIT II

Classification of chemicals used in plant disease control and their characteristics.

UNIT III

Chemicals in plant disease control, viz., fungicides, bactericides,nematicides, antiviral chemicals, botanicals and plant activators.

UNIT IV

Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

UNIT V

Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio,
factor affecting fungicides.

UNIT VI

General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its
management.

Practical

Acquaintance with formulation of different fungicides and plant protection appliances. Formulation of fungicides, bactericides and nematicides; *in vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides based on active ingredients against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogen; methods of application of chemicals.

Suggested Readings

Bindra OS & Singh H. 1977. *Pesticides - An Application Equipment*. Oxford & IBH, New Delhi.

Nene YL & Thapliyal PN. 1993. *Fungicides in Plant Disease Control.* 3rd Ed. Oxford & IBH, New Delhi.

Torgeson DC (Ed.). 1969. *Fungicides*. Vol. II. *An Advanced Treatise*. Academic Press, New York.

Vyas SC. 1993. *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

12.PL PATH 512 ECOLOGY AND MANAGEMENT OF SOIL-BORNE PLANT PATHOGENS 2+1

Objective

To provide knowledge on soil-plant disease relationship.

Theory

UNIT I

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi.Types of biocontrol agents.

UNIT II

Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

UNIT III

Suppressive soils, biological control- concepts and potentialities for managing soil borne pathogens. Soil fungicides, persistence of fungicides in soil and microbial degradation .

Practical

Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil-borne pathogens by antagonistic microorganisms.

Suggested Readings

Baker KF & Snyder WC. 1965. *Ecology of Soil-borne Plant Pathogens*.John Wiley, New York.

Cook RJ & Baker KF. 1983. *The Nature and Practice of Biological Control of Plant Pathogens*. APS, St Paul, Minnesota.

Garret SD. 1970. *Pathogenic Root-infecting Fungi*. Cambridge Univ. Press, Cambridge, New York.

Hillocks RJ & Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CABI, Wallington.

Parker CA, Rovira AD, Moore KJ & Wong PTN. (Eds). 1983. *Ecology andManagement of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

13.PL PATH 513 DISEASE RESISTANCE IN PLANTS 2+0

Objective

To acquaint with disease resistance mechanisms in plants.

Theory

UNIT I

Introduction and historical development, dynamics of pathogenicity,process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.

UNIT II

Disease escapes, disease tolerance, disease resistance, types of resistance,identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNIT III

Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

UNIT IV

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment. Breeding for disease resistance

Suggested Readings

Deverall BJ. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, New York.

Mills Dallice et al.1996. *Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction.* APS, St Paul,Minnesota.

Parker J. 2008. *Molecular Aspects of Plant Diseases Resistance*. Blackwell Publ.

Robinson RA. 1976. *Plant Pathosystems*. Springer Verlag, New York.

Singh BD. 2005. *Plant Breeding – Principles and Methods*. 7th Ed. Kalyani Publ., Ludhiana

Van der Plank JE. 1975. *Principles of Plant Infection*. Academic Press, New York.
Van der Plank JE. 1978. *Genetic and Molecular Basis of Plant Pathogenesis*. Springer Verlag. New York.
Van der Plank JE. 1982. *Host Pathogen Interactions in Plant Disease*. Academic Press, New York.
Van der Plank JE. 1984. *Disease Resistance in Plants*. Academic Press,New York.

14.PL PATH 514 INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS 1+1

Objective
To teach the students about the different groups of insects that vector plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

Theory
UNIT I
History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.
UNIT II
Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.
UNIT III
Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.
UNIT IV
Transmission of phytoplasma and fastidious vascular bacteria by leaf hoppers and plant hoppers.
UNIT V
Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vectormanagement.

Practical
Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies.

Suggested Readings
Basu AN. 1995. *Bemisia tabaci (*Gennadius*) - Crop Pest and Principal Whitefly Vector of Plant Viruses.* Oxford & IBH, New Delhi.
Harris KF & Maramarosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.
Maramorosch K & Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.
Youdeovei A & Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

15.PL PATH 515 BIOLOGICAL CONTROL OF PLANT DISEASES 2+1

Objective
To study principles and application of ecofriendly and sustainable management strategies of plant diseases.

Theory

UNIT I

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

UNIT II

Types of biological interactions, competition, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

UNIT III

Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of different bioagents.

UNIT IV

Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

Practical

Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in vitro and in vivo* conditions. enumeration of soil and bioformulations.

Suggested Readings

Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*.Cambridge Univ. Press, Cambridge.

Cook RJ & Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens*. APS, St. Paul, Mennisota.

Dinakaran,D.Arjunanan,G. and Karthikeyan,G.2003.Biolgical control of plant diseases. Anbil Dharmalingam Agricultural College and Research Institute, T.N.A.U., Thiruchirappalli

Fokkemma MJ. 1986. *Microbiology of the Phyllosphere*. Cambridge Univ.Press, Cambridge.

Gnanamanickam SS (Eds). 2002. *Biological Control of Crop Diseases*.CRC Press, Florida.

Heikki MT & Hokkanen James M (Eds.). 1996. *Biological Control -Benefits and Risks*. Cambridge Univ. Press, Cambridge.

Mukerji KG, Tewari JP, Arora DK & Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi.

16.PL PATH 516 INTEGRATED DISEASE MANAGEMENT 2+1

Objective

To emphasize the importance and need of IDM in the management of diseases of important crops.

Theory

UNIT I

Introduction, definition, concept and tools of disease management,components of integrated disease management- their limitations and implications.

UNIT II

Development of IDM- basic principles, biological, chemical and cultural management of diseases.

UNIT III

IDM in important crops- rice, wheat, coconut,cotton, sugarcane, chickpea, black pepper , ginger ,other spices, rapeseed, mustard,pearlmillet, *kharif* pulses, vegetable crops and fruit crops.

Practical

Application of biological, cultural, chemical and biocontrol agents, their compatibility and integration in IDM; demonstration of IDM in important crops as project work.

Suggested Readings

Gupta VK & Sharma RC. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.

Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS & Deshpande Jayashree (Eds.). 2004. *Biotechnological Approaches for the Integrated Management of Crop Diseases*. Daya Publ. House, New Delhi.

Sharma RC & Sharma JN. (Eds). 1995. *Integrated Plant Disease Management*. Scientific Publ., Jodhpur.

17.PL PATH 517 MUSHROOM PRODUCTION TECHNOLOGY 2+1

Objective

To develop mushroom cultivation skills for entrepreneurial activity.Historical development of mushroom cultivation and present status of mushroom industry in India.

Theory

UNIT I

Historical development of mushroom cultivation and present status,taxonomy, classification, food, medicinal value, uses of mushroom, edible and poisonous mushrooms.

UNIT II

Life cycle of cultivated mushrooms, reproduction and strain improvement,maintenance of pure culture, preparation of spawn and facilities required for establishing commercial spawn lab, project formulation and construction of mushroom shed

UNIT III

Preparation of substrate for mushroom cultivation, long, short and indoor composting methods, formulae for different composts and their computation, qualities and testing of compost, uses of spent mushroom compost/substrate.

UNIT IV

Facilities for setting up mushroom farm for seasonal and environmentally control cultivation, requirement and maintenance of temperature, relative humidity, CO2, ventilation in cropping rooms, cultivation technology of *Agaricus bisporus*, *Pleurotus* sp., *Calocybe indica*, *Lentinus edodes*, *Volvariella*, *Auricularia* and *Ganoderma lucidum.*

UNIT V

Insect pests, diseases and abnormalities of cultivated mushroom and their management, post harvest processing and value addition, economics of mushroom cultivation, biotechnology and mushroom cultivation.

Practical

Preparation of spawn, compost, spawning, casing, harvesting and postharvest handling of edible mushroom; identification of various pathogens,competitors of various mushroom.

Suggested Readings

Chadha KL & Sharma SR. 2001. *Advances in Horticulture* (*Mushroom*). Vol. XIII. Malhotra Publ. House, New Delhi.

Chang ST & Hays WA. 1997. *The Biology and Cultivation of Edible Mushrooms*. Academic Press, New York.

Chang ST & Miles PG. 2002. *Edible Mushrooms and their Cultivation*. CRC Press, Florida.

Kapur JN. 1989. *Mushroom Cultivation*. DIPA, ICAR, New Delhi.

Dhar BL. 2005. *Cultivation Technology of High Temperature Tolerant White Button Mushroom*. DIPA, ICAR, New Delhi.

18.PL PATH 518 EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES 2+1

Objective

To acquaint with the principles of epidemiology and its application in disease forecasting.

Theory

UNIT I

Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis.

UNIT II

Common and natural logrithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens.

UNIT III

Survey, surveillance and vigilance, crop loss assessment and models.

UNIT IV

Principles and pre-requisites of forecasting, systems and factors affecting various components of forecastings, some early forecasting, procedures based on weather and inoculum potential, modeling disease growth and disease prediction.

Practical

Measuring diseases, spore dispersal and trapping, weather recording, survey, multiplication of inoculum, computerized data analysis, function fitting, model preparation and validation.

Suggested Readings

Campbell CL & Madden LV. 1990. *Introduction to Plant Disease Epidemiology*. John Wiley & Sons. New York

Cowling EB & Horsefall JG. 1978. *Plant Disease*. Vol. II. Academic Press, New York.

Laurence VM, Gareth H & Frame Van den Bosch (Eds.). *The Study of Plant Disease Epidemics*. APS, St. Paul, Minnesota.

Nagarajan S & Murlidharan K. 1995. *Dynamics of Plant Diseases*. Allied Publ., New Delhi.

Thresh JM. 2006. *Plant Virus Epidemiology*. Advances in Virus Research 67, Academic Press, New York.
Van der Plank JE. 1963. *Plant Diseases Epidemics and Control*. Academic Press, New York.
Zadoks JC & Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London.

19.PL PATH 519 POST HARVEST DISEASES 2+1

Objective
To acquaint with post harvest diseases of agricultural produce and their ecofriendly management.

Theory
UNIT I
Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as preharvest and post-harvest, merits and demerits of biological/phytoextracts in controlling post-harvest diseases.
UNIT II
Types of post harvest problems both by biotic and abiotic causes, fructosphere colonization, competitive, saprophytic ability, antibiosis, induced resistance, microbial associations, concept, operational mechanisms and its relevance in control.
UNIT III
Factors governing post harvest problems both as biotic and abiotic, role of physical environment, agro-ecocystem leading to quiescent infection,operational mechanisms and cultural practices in perpetuation of pathogens,pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.Isolation, characterization and maintenance of pathogens, role of different storage.
UNIT IV
Integrated approach in controlling diseases and improving the shelf life of produce, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for any health hazard, knowledge of Codex Alimentarious for each product and commodity.

Practical
Isolation characterization and maintenance of pathogens, role of different storage conditions on disease development, application of antagonists against pathogens *in vivo* and *in vitro* conditions. Comparative efficacy of different chemicals, fungicides, phytoextracts and bioagents.

Suggested Readings
Pathak VN. 1970. *Diseases of Fruit Crops and their Control*. IBH Publ.,New Delhi.
Chaddha KL & Pareek OP. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.

20. PL PATH 520 PLANT QUARANTINE 2+0

Objective
To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

UNIT III

Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.

UNIT IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

Rajeev K & Mukherjee RC. 1996. Role of Plant Quarantine in IPM. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

21. PL.PATH.521 EXTENSION PLANT PATHOLOGY 1+ 1

Objective

To study the role of Plant Pathology in agriculture, its significance to farmers and students in agriculture and programmes related to agriculture.

Theory

UNIT I

Importance of Extension plant pathology, History of EPP identification and diagnosis of diseases symptoms of infectious, fungal, viral, bacterial, phytoplasmal diseases

UNIT II

Non-infectious diseases, deficiency diseases, phanerorganic parasites, diseases due to environmental factors, steps in diagnosis, management of crop diseases, preparation of exhibits for farm fairs, for farm exhibitionsand conduct of agroclinics

UNIT III

Preparation of scientific articles for farm journals, safe and appropriate use of fungicides, formulation, application of fungicides, study of fungicides, botanicals, biopesticides, pp equipments, biocontrol agents in plant diseases control, isolation of bniocontrol agents, mass multiplication, formulation, delivery and mushroom cultivation.

Practical

Field visit to study the symptom and diagnosis of the various, field , vegetable plantation, spices and ornamental plants, preparation of fungicides,study of pp equipments, preparation of exhibits for farmclinics, exhibitions, article writing for farm journals, islation of biocontrol agents from rhizosphere, purification, characterisation, mass multiplication, study on mushroom culture.

Suggested readings

Agrios GN 2007 Palant Pathology 7th Ed. Academic Press , New York.

Barnes, L.W.1994. The role of plant clinics in disease diagnosis and identification- A North American Perspective. In Ann, Rev. Phyto path., 32: 601-609.

Bandion, Hooper G.R, Mathre D.E & Carroll R.B.1990. Laboratory Exercises in Plant Pathology- An Instructional Kit. Scientific Publication. Jodhpur.

Charles Chupp, 1998. Manual of vegetable plant diseases. Discovery Publishing House, New Delhi.

Fox RTV- 1993 Principles of Diagnostic Techniques in Plant Pathology CABI Willington.

Horsfall, J.G 1959. Plant Pathology- Problems and progress: Maidson Univ.W.S.

Horsfall, J.G and Cowling E.B. 1977. Plant diseases- An advanced treatise. New York Publishing, New York.

Mathews REF.1993. Diagnosis of plant virus diseases. CRC Press, Florida.

Vishanavat.K.Kolte, S.J. 2005- Essentials of Phytopathological techniques. Kalyani Publishers, Noida.

Ph.D courses

1.PL PATH 601 ADVANCED MYCOLOGY 2+1

Objective

To acquaint with the latest advances in Mycology.

Theory

UNIT I

General introduction, historical development and advances in mycology.

UNIT II

Recent taxonomic criteria, morphological criteria for classification.Serological, Chemical (chemotaxonomy), Molecular and Numerical(Computer based assessment) taxonomy.

UNIT III

Interaction between groups: Phylogeny. Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti. Morphology and reproduction of representative plant pathogenic genera from different groups of fungi. Sexual reproduction in different groups of fungi. Anamorph –teleomorph relationships

UNIT IV

Population biology, pathogenic variability/vegetative compatibility.

UNIT V

Heterokaryosis and parasexual cycle. Sex hormones in fungi.Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation. Industrial uses of fungi.

Practical

Study of conidiogenesis- phialides, porospores, arthospores. Study of fruit bodies in Ascomycotina. Identification of fungi up to species level. Study of hyphal anastomosis. Morphology of representative plant pathogenic genera from different groups of fungi.Anamorph –teleomorph relationships.

Suggested Readings

Alexopoulos CJ, Mimms CW & Blackwell M. 1996. *Introductory Mycology*. John Wiley & Sons, New York.

Dube HC. 2005. *An Introduction to Fungi*. 3rd Ed. Vikas Publ. House, New Delhi.

Kirk PM, Cannon PF, David JC & Stalpers JA. (Eds.). 2001. *Ainswsorth and Bisby's Dictionary of Fungi*. 9th Ed., CABI, Wallington.

Ulloa M & Hanlin RT. 2000. *Illustrated Dictionary of Mycology*. APS, St. Paul, Mennisota.

Webster J & Weber R. 2007. *Introduction to Fungi*. Cambridge Univ.Press, Cambridge.

2. PL PATH 602 ADVANCED VIROLOGY 2+1

Objective

To educate about the advanced techniques and new developments in the field of Plant Virology.

Theory

UNIT I

Mechanism of virus transmission by vectors, virus-vector relationship, bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses, virus replication, assembly and architecture, ultrastructural changes due to virus infection, variation, mutation and virus strains.

UNIT II

Immunoglobulin structure and functions of various domains, methods of immunodiagnosis, hybridoma technology and use of monoclonal antibodies in identification of viruses and their strains, Polymerase Chain Reaction.

UNIT III

Genome organization, replication, transcription and translational strategies of pararetroviruses and gemini viruses, satellite viruses and satellite RNA genome organization in tobamo-, poty-, bromo, cucummo, ilar and tospoviruses.

UNIT IV

Gene expression and regulation, viral promoters, molecular mechanism of host virus interactions, virus induced gene, molecular mechanism of vector transmission, symptom expression, viroids and prions.

UNIT V

Genetic engineering with plant viruses, viral suppressors, a RNA dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants.

UNIT VI

Techniques and application of tissue culture. Origin, evolution and interrelationship with animal viruses.

Practical

Purification of virus(es), SDS-PAGE for molecular weight determination,production of polyclonal antiserum, purification of IgG and conjugate preparation, serological techniques (i) DAC-ELISA (ii) DAS -ELISA (iii)DIBA (iv) Western blots (v) (ab) 2-ELISA, vector transmission (one each with aphid, leaf hopper and whitefly), methods for collecting vectors and their maintenance, nucleic acid isolation, DOT-blot, southern hybridization,probe preparation and autoradiography, PCR application and viral genome cloning, sequencing annotation of genes.

Suggested Readings

Davies 1997. *Molecular Plant Virology: Replication and Gene Expression*. CRC Press, Florida.

Fauquet *et al*. 2005. *Vius Taxonomy*. VIII Report of ICTV. Academic Press, New York.

Gibbs A & Harrison B. 1976. *Plant Virology - The Principles.* Edward Arnold, London.

Jones P, Jones PG & Sutton JM. 1997. *Plant Molecular Biology: Essential Techniques*. John Wiley & Sons, New York.

Khan JA & Dijkstra. 2002. *Plant Viruses as Molecular Pathogens*.Howarth Press, New York.

Maramorosch K, Murphy FA & Shatkin AJ. 1996. *Advances in VirusResearch*. Vol. 46. Academic Press, New York.

Narayanasamy,P. and Doraiswamy,S.2003.Plant viruses and viral diseases.New Century Book House(P) Ltd.,Chennai.

Pirone TP & Shaw JG. 1990. *Viral Genes and Plant Pathogenesis*. Springer Verlag, New York.

Roger Hull 2002. *Mathew's Plant Virology* (4th Ed.). Academic Press, NewYork.

Thresh JM. 2006. *Plant Virus Epidemiology.* Advances in Virus Research 67. Academic Press, New York.

3. PL PATH 603 ADVANCED BACTERIOLOGY 2+1

Objective

To provide knowledge about the latest advances in phytobacteriology.

Theory

UNIT I

Current approaches for the characterization and identification of phytopathogenic bacteria. Ultrastructures and biology of bacteria.

UNIT II

Current trends in taxonomy of phytopathogenic procarya.

UNIT III

Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development. Mechanism of wilt (*Ralstonia solanacearum*) development, mechanism of soft rot (*Erwinia* spp.) development, mechanism of Crown gall formation (*Agrobacterium tumefaciens*).

UNIT IV

Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R-genes, Avr-genes, hrp genes,Effector protein.

UNIT V

Molecular variability among phytopathogenic procarya and possible host defense mechanism(s). Genetic engineering for management of bacterial plant pasthogens-gene silencing, RNA technology.

UNIT VI

Epidemiology in relation to bacterial plant pathogens. Development of diagnostic kit.

UNIT VII

Beneficial prokaryotes- Endophytes, PGPR, phylloplane bacteria and their role in disease management. Endosymbionts for host defence.

Practical

Pathogenic studies and race identification; plasmid profiling of bacteria;fatty acid profiling of bacteria; RAPD prolfiling of bacteria and variability status; Endospore, Flagiler staining; test for secondary metabolite production, cyanides, EPS, siderophore; specific detection of phytopathogenic bacteria using species/pathovar specific primers. Basic techniques in diagnostic kit development, molecular tools to identify phytoendosymbionts.

Suggested Readings

Dale JW & Simon P. 2004. *Molecular Genetics of Bacteria*. John Wiley & Sons, New York.

Garrity GM, Krieg NR & Brenner DJ. 2006. *Bergey's Manual of Systematic Bacteriology: The Proteobacteria.* Vol. II. Springer Verlag, New York.

Gnanamanickam SS. 2006. *Plant-Associated Bacteria*. Springer Verlag, New York.

Mount MS & Lacy GH. 1982. *Plant Pathogenic Prokaryotes*. Vols. I, II. Academic Press, New York.

Sigee DC. 1993. *Bacterial Plant Pathology: Cell and Molecular Aspects*.Cambridge Univ. Press, Cambridge.

Starr MP. 1992. *The Prokaryotes*. Vols. I – IV. Springer Verlag, New York.

4.PL PATH 604 MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION* 2+1

Objective

To understand the concepts of molecular biology and biotechnology in relation to host-pathogen interactions.

Theory

UNIT I

Importance and role of biotechnological tools in Plant Pathology- Basic concepts and principles to study host pathogen relationship.

UNIT II

Molecular basis of host-pathogen interaction- fungi, bacteria and viruses; recognition system, signal transduction.

UNIT III

Induction of defense responses- pathogenesis related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance, Programmed Cell Death, Viral induced gene silencing.

UNIT IV

Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes.

UNIT V

Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Practical

Protein, DNA and RNA isolation, Plasmids extraction,PCR analysis, DNA and Protein electrophoresis, bacterial transformation.

Suggested Readings

Chet I. 1993. *Biotechnology in Plant Disease Control*. John Wiley & Sons, New York.

Gurr SJ, Mc Pohersen MJ & Bowlos DJ. (Eds.). 1992. *Molecular Plant Pathology - A Practical Approach.* Vols. I & II, Oxford Univ. Press, Oxford.

Mathew JD. 2003. *Molecular Plant Pathology*. Bios Scientific Publ., UK.

Ronald PC. 2007. *Plant-Pathogen Interactions: Methods in Molecular Biology*. Humana Press, New Jersey.

Stacey G & Keen TN. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

5. PL PATH 605 PRINCIPLES AND PROCEDURES OF CERTIFICATION 1+0

Objective

To acquaint with certification procedures of seed and planting material.

Theory

UNIT I

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD etc. in certification and quality control.

UNIT II

Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical

purity, germination percentage, seed health etc.

UNIT III

Fixing tolerance limits for diseases and insect pests in certification and quality control programmes. Methods used in certification of seeds, vegetative propagules and *in vitro* cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

Suggested Readings

Association of Official Seed Certifying
Agencies.http://www.aosca.org/index.htm.
Hutchins D & Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, UK.
ISHI-v*eg Manual of Seed Health Testing Methods.*
http://www.worldseed.org/enus/
international_seed/ishi_vegetable.html
ISHI-F *Manual of Seed Health Testing Methods*.
http://www.worldseed.org/en-us/international_seed/ishi_f.html
ISTA *Seed Health Testing Methods*. http://www.seedtest.org/en/content---
1--1132--241.html
Tunwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Department of
Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi.
US National Seed Health System. http://www.seedhealth.org/

List of Journals

- *Annals of Applied Biology* – Cambridge University Press, London
- *Annual Review of Phytopathology* – Annual Reviews, Palo Alto, California
- *Annual Review of Plant Pathology* - Scientific Publishers, Jodhpur
- *Canadian Journal of Plant Pathology* - Canadian Phytopathological Society, Ottawa
- *Indian Journal of Biotechnology* - National Institute of Science Communication and Information Resources, CSIR, New Delhi
- *Indian Journal of Mycopathological Research*- Indian Society of Mycology, Kolkata.
- *Indian Journal of Virology* - Indian Virological Society, New Delhi
- *Indian Phytopathology* - Indian Phytopathological Society, New Delhi
- *Journal of Mycology and Plant Pathology* - Society of Mycology and Plant Pathology,Udaipur
- *Journal of Phytopathology* - Blackwell Verlag, Berlin
- *Mycologia* - New York Botanical Garden, Pennsylvania
- *Mycological Research* - Cambridge University Press, London
- *Physiological Molecular Plant Pathology* - Academic Press, London
- *Phytopathology* - American Phytopathological Society, USA
- *Plant Disease* - The American Phytopathological Society, USA
- *Plant Disease Research* – Indian Society of Plant Pathologists, Ludhiana
- *Plant Pathology* - British Society for Plant Pathology, Blackwell Publ.
- *Review of Plant Pathology* - CAB International, Wallingford
- *Virology*- New York Academic Press

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- www.apsnet.org/journals
- www.cabi_publishing.org
- www.springer.com/life+Sci/agriculture
- www.backwellpublishing.com
- www.csiro.au
- www.annual-reviews.org

Suggested Broad Topics for Master's and Doctoral Research

- Pathogenesis and characterization of plant pathogens
- Survey and surveillance
- Induction of resistance using biotic and abiotic elicitors
- Variability in plant pathogens

- Plant-Virus-Vector relationships
- Genome organization of plant pathogens
- Dynamics of plant pathogen propagules and their biology
- Molecular tools in disease diagnosis
- Molecular mechanisms of pathogenesis in crops and seeds
- Rhizosphere in pathogenesis of seed-borne plant pathogens
- Transgenic resistance
- Development of disease prediction models in disease forecasting
- Integrated Disease Management
- Molecular Taxonomy of different plant pathogens
- Development of Rapid Diagnostic methods
- Development and Formulation of Improved Biocontrol Agent

VII MICROBIOLOGY

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
MICRO 501*	PRINCIPLES OF MICROBIOLOGY	3+1
MICRO 502*	MICROBIAL PHYSIOLOGY AND METABOLISM	3+1
MICRO 503*	MICROBIAL GENETICS	2+1
MICRO 504*#	SOIL MICROBIOLOGY	2+1
MICRO 505* @	MICROBIAL BIOTECHNOLOGY	2+1
MICRO 506*	FOOD MICROBIOLOGY	2+1
MICRO 507	BACTERIOPHAGES	1+1
MICRO 508	ENVIRONMENTAL MICROBIOLOGY	2+1
MICRO 509**	PLANT-MICROBE INTERACTIONS	3+0
MICRO 510	INDUSTRIAL MICROBIOLOGY	2+1
MICRO 511	BIOFERTILIZER TECHNOLOGY	1+1
MICRO 512	CYANOBACTERIAL AND ALGAL BIOTECHNOLOGY	2+0
MICRO 591	MASTER'S SEMINAR	1+0
MICRO 599	MASTER'S RESEARCH	20

*Compulsory for Master's programme; **Compulsory for Doctoral programme
#Can be cross-listed with Soil Science; @Can be cross-listed with Biotechnology

1.MICRO 501 PRINCIPLES OF MICROBIOLOGY 3+1

Objective

To teach the students about basics in development of microbiology,differences in prokaryotes and eukaryotic cell and classification of prokaryotes.

Theory

UNIT I

Development of Microbiology in the 18 th and 19 th century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea. Classification of prokaryotes – Basic principles and techniques used in bacterial classification.

UNIT II

Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications.

UNIT III

Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes.

UNIT IV

Viruses – morphology, classification and replication of plant, animal and bacterial viruses. Cultivation methods of viruses. Immune response – specific and non-specific resistance. Normal microflora of human body; some common bacterial and viral diseases of humans and animals.

Practical

Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food). Enrichment culture technique – isolation of asymbiotic, symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria. Use of selective media, antibiotic resistance and isolation of antibiotic producing microorganisms. Morphological, physiological and biochemical characterization of bacteria.

Suggested Readings

Brock TD. 1961. *Milestones in Microbiolog*y. Infinity Books.

Pelczar MJ, Chan ECS & Kreig NR. 1997. *Microbiology: Concepts and Applicatio*n. Tata McGraw Hill.

Stainier RY, Ingraham JL, Wheelis ML & Painter PR. 2003. *General Microbiolog*y. MacMillan.

Tauro P, Kapoor KK & Yadav KS. 1996. *Introduction to Microbiolog*y.Wiley Eastern.

2.MICRO 502 MICROBIAL PHYSIOLOGY AND METABOLISM 3+1

Objective

To teach students about cell cycle, growth and practical training on methods to determine microbial growth.

Theory

UNIT I

Structure, function, biosynthesis and assembly of various cellular components of prokaryotes. Archea and fungi. Transport of solutes across the membrane.

UNIT II

Microbial growth. Cell cycle and cell division. EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Biosynthesis of macromolecules. Regulation of microbial metabolism.

UNIT III

Effect of chemicals and other environmental factors on growth.Morphogenesis and cellular differentiation.

UNIT IV

Important metabolic patterns in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs.

Practical

Use of simple techniques in laboratory (Colorimetry, Centrifugation, Electrophoresis and GLC). Determination of viable and total number of cells. Measurement of cell size. Gross cellular composition of microbial cell. Growth – Factors affecting growth. Sporulation and spore germination in bacteria. Protoplasts formation. Induction and repression of

enzymes.

Suggested Readings

Doelle HW. 1969. *Bacterial Metabolis*m. Academic Press.

Gottschalk G. 1979. *Bacterial Metabolism.* Springer Verlag.

Moat AG. 1979. *Microbial Physiolog*y. John Wiley & Sons.

Sokatch JR. 1969. *Bacterial Physiology and Metabolism.* Academic Pres*s.*

3. MICRO 503 MICROBIAL GENETICS 2+1

Objective

To acquaint the learners regarding molecular concepts of bacteria and viruses and impact of gene cloning on human welfare.

Theory

UNIT I

Prokaryotic, eukaryotic and viral genome. Replication of Eukaryotic, Prokaryotic and Viral DNA. Structure, classification and replication of plasmids.

UNIT II

Molecular basis of mutation. Biochemical genetics and gene mapping by recombination and complementation. Fine gene structure analysis. Fungal genetics.

UNIT III

Gene transfer in bacteria through transformation, conjugation and transduction; gene mapping by these processes. Transposable elements.

UNIT IV

Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Regulation of gene expression. Recent advances in DNA repair and mutagenesis, Genetic basis of Cancer and cell death.

Practical

Inactivation of microorganisms by different mutagens. Production, isolation and characterization of mutants. Determination of mutation rate. Isolation, characterization and curing of plasmids. Transfer of plasmid by conjugation, electroporation. Tetrad and random spore analysis.

Suggested Readings

Birge EA. 1981. *Bacterial and Bacteriophage Genetic*s. Springer Verlag.

Gardner JE, Simmons MJ & Snustad DP. 1991. *Principles of Genetic*s. John Wiley& Sons.

Lewin B.1999. *Gen*e. Vols. VI-IX. John Wiley & Sons.

Maloy A & Friedfelder D. 1994. *Microbial Genetic*s. Narosa.

Scaife J, Leach D & Galizzi A 1985. *Genetics of Bacteri*a. Academic Press.

William Hayes 1981. *Genetics of Bacteri*a. Academic Press.

4.MICRO 504 SOIL MICROBIOLOGY 2+1

Objective

Objective of this course is to teach students regarding basics of microbiology related to soil including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UNIT I

Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.

UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere, Biofertilizers, soil enzyme activities and their importance.

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials. Biochemical composition and biodegradation of soil organic matter and crop residues.

UNIT IV

Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development.

Practical

Determination of soil microbial population; Soil microbial biomass; Decomposition studies in soil, Soil enzymes; Measurement of important soil microbial processes such as ammonification, nitrification. N2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients;

Study of rhizosphere effect.

Suggested Readings

Martin Alexander 1977. *Soil Microbiology*. John Wiley.

Paul EA. 2007. *Soil Microbiology, Ecology and Biochemistry*. 3 rd Ed. Academic Press.

Sylvia *et al.* 2005. *Principles and Applications of Soil Microbiology*. 2 nd Ed. Pearson Edu.

van Elsas JD, Trevors JT & Wellington EMH. 1997. *Modern Soil Microbiology*. Marcel Dekker.

5.MICRO 505 MICROBIAL BIOTECHNOLOGY 2+1

Objective

To teach students about industrially useful microorganisms and use of fermentor for the production of various primary and secondary metabolites.

Theory

UNIT I

Introduction, scope and historical development; Isolation, screening and genetic improvement of industrially important microorganisms.

UNIT II

Types of fermentation systems; production of various primary and secondary metabolities, e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc.

UNIT III

Process scale up steps: laboratory, pilot plant and industrial scales. Down stream processing; Over-production of metabolities; Bioreactor operations, process control.

UNIT IV

Fermented beverages; Production of single cell protein; Steroid transformation; Immobilization of cells/enzymes; Silage production; Waste water treatment.

UNIT V

Use of genetically-engineered microorganisms in biotechnology; Bioinsecticides, biofertilizers, etc. Microbiologically-produced food colours and flavours. Retting of flax.

Practical

Isolation of industrially important microorganisms, their maintenance and improvement. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery; Study of bio-reactors and their
operation: Production of biofertilizers.

Suggested Readings

Cruger W & Cruger A. 2004. *Biotechnology - A Textbook of Industrial Microbiology*. 2 nd Ed. Panima.

Ward OP. 1989. *Fermentation Biotechnolog*y. Prentice Hall.

Wiseman A. 1983. *Principles of Biotechnology.* Chapman & Hall.

6. MICRO 506 FOOD MICROBIOLOGY 2+1

Objective

To familiarize the students with recent advances in food microbiology including fermented foods, dairy, food preservation, detection of food-borne diseases, their control measures.

Theory

UNIT I

Introduction and scope; Food Microbiology – A many faceted science; Interrelationship of food microbiology with other sciences; Perspectives on food safety and Food Biotechnology.

UNIT II

Factors of special significance in Food Microbiology – Principles influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria; Microbial spoilage of foods- meat, milk, fruits, vegetables and their products; Microbiology of water -Sources of contamination and methods of estimation-Food poisoning and food-borne pathogenic bacteria.

UNIT III

Food fermentation; Fermented dairy, vegetable, meat products; Preservatives and preservation methods – physical methods, chemical preservatives and natural antimicrobial compounds. Bacteriocins and their applications; Biologically based preservation systems and probiotic
bacteria.

UNIT IV

Advanced techniques in detecting food-borne pathogens and toxins. Hurdle technology and Hazard analysis. Critical control point systems in controlling microbiological hazards in foods.

Practical

Statutory, recommended and supplementary tests for microbiological analysis of various foods: Baby foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers and water.

Suggested Readings

Bibek Ray.1996. *Fundamentals of Food Microbiology*. CRC Press.
Frazier WC & Westhoff DC. 1991. *Food Microbiology*. 3 rd Ed. Tata McGraw Hill.
George J Banwart. 1989. Basic Food Microbiology. AVI.
James M Jay. 1987. Modern Food Microbiology. CBS.
Peppler HJ & Perlman D.1979. *Microbial Technology*. 2 nd Ed. Academic Press.

7. MICRO 507 BACTERIOPHAGES 1+1

Objective

To familiarize students about phages and phage- bacterial interactions.

Theory

UNIT I

Historical developments and classification of bacteriophages.

UNIT II

Physiology, biochemistry, enzymology and molecular biology of phage-bacterial interactions.

UNIT III

Structure, functions and life cycles of different DNA, RNA, lytic and lysogenic phages.

UNIT IV

Phages in the development of molecular biology and genetic engineering.

Practical

Titration of phages and bacteria. Absorption of phages. Preparation of phage stocks. Isolation of new phages and phage resistant bacteria. One step growth curve, phage bursts. Induction of lambda. Complementation of T4 *rII* mutants etc.

Suggested Readings

Birge EA. 2000. *Bacterial and Bacteriophage Genetics.* Springer-Verlag.
Mathew CK. 1972. *Bacteriophage Biochemistry*. Am. Chemical Soc.
Mathew CK, Kutter EM, Mosig G & Berget P. 1988. *Bacteriophage T*4.Plenum Press.
Nancy T & Trempy J. 2004. *Fundamental Bacterial Genetic*s. Blackwell.
Stent SG. 1963. *Molecular Biology of Bacterial Viruse*s. WH Freeman.
Winkler J, Ruger W & Wackernagel W. 1979. *Bacterial, Phage and Molecular Genetics - An Experimental Course.* Narosa.
Winkler U & Ruhr W. 1984. *Bacteria, Phage and Molecular Genetic*s.ALA.

8.MICRO 508 ENVIRONMENTAL MICROBIOLOGY 2+1

Objective

To teach and create awareness regarding environment, water, soil, air pollution and bioremediation.

Theory

UNIT I

Scope of environmental microbiology. An overview of microbial niches in global environment and microbial activities. Microbiology of air, outdoor and indoor environment in relation to human, animal and plant health and economic activities.

UNIT II

Microbiology of natural waters. Environmental pollution – Deleterious and beneficial role of microorganisms. Environmental microbiology in public health. Microorganism in extreme environments, Environmental determinants that govern extreme environment- Air water interface,

extreme of pH, Temperature, Salinity, Hydrostatic pressure.

UNIT III

Microbial technology in pollution abatement, waste management and resource recovery in metal, petroleum and bioenergy fields. Biofuels. Global environmental problems

UNIT IV

Microbial upgradation of fossil fuels and coal gas. Microbial interaction in rumen and gastrointestinal tract. Biodeterioration and Bioremediation. Biodegradation and xenobiotic compounds

Practical

Analysis of natural waters, waste waters and organic waste in relation to water pollution assessment, pollution strength and resource quantification; Quality control tests, waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge processes, biofilter and fluidized bed process.

Suggested Readings

Campbell R. 1983. *Microbial Ecology*. Blackwell.

Hawker LE & Linton AH. 1989. *Microorganisms Function, Form andEnvironmen*t. 2 nd Ed. Edward Arnold.

Mitchell R. 1992. *Environmental Microbiology*. John Wiley & Sons.

Richards BN. 1987. *Microbes of Terrestrial Ecosyste*m. Longman.

9.MICRO 509 PLANT-MICROBE INTERACTIONS 2+1

Objective

To familiarize the students with the biochemical and biophysical mechanisms, genetics, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces of beneficial and pathogenic plant microbe interactions. Molecular analysis of relevant factors in the plant and microbes, and components that modulate plant-microbe interactions for soil and plant health for sustaining crop productivity.

Theory

UNIT I

Different interfaces of interactions - Plant-microbe, microbe-microbe, soil-microbe,

soil-plant-microbe interactions leading to symbiotic (rhizobial and mycorrhizal), associative, endophytic and pathogenic interactions. Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow, Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, T-RFLP.

UNIT II

Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.

UNIT III

Methodology/resources to study plant-microbe interaction, recombinant inbred lines, biosensors, transcriptome profiling, metabolic profiling, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces.

UNIT IV

Plant and microbial gene expression and signal exchange, global and specific regulators for different interactions. Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants.

Practicals

Isolation of rhizosphere microorganisms, antagonists, Mycoparasites, PGPR; analysis of root exudates, chemotaxis, motility; root and seed colonization assay, environmental monitoring, IAR, genetic markers; host pathogen interactions, bacteria , fungi and virus, hypersensitive reactions, isolation of endophytes, bacteria, fungi; colonization assay for VAM, induced systemic resistance.

Suggested Readings

Kosuge T & Nester EW. 1989. *Plant-Microbe Interactions: Molecular and Genetic Perspective*s. Vols I-IV. McGraw Hill.

Verma DPS & Kohn TH. 1984. *Genes Involved in Microbe-Plant Interactions.* Springer Verlag.

*Molecular Plant-Microbe Interaction*s. Journal Published by APS.

10. MICRO 510 INDUSTRIAL MICROBIOLOGY 2+1

Objective

To expose the students to the commercial exploitation of microorganisms for production of useful products. Focus will be on understanding of the techniques involved and the application of microorganisms for agribusiness purpose.

Theory

UNIT I

Biofermentor; Production of wine, beer, lactic acid, acetic acid (vinegar), citric acid, antibiotics, enzymes, vitamins and single cell proteins. Biofuels: Production of ethanol, biogas and hydrogen production.

UNIT II

Brief introduction to bacterial, fungal and insect diseases, Types of chemicals/pesticides used for disease control. Vaccines. Bioagents and Biopesticides Biocontrol agents and their scope in control of plant diseases, nematodes and insect pests. Introduction to phytopathogens, symptoms,

pathogenesis molecular aspects of plant pathogens, host-pathogens interactions, host defense mechanisms, disease forecasting and assessment of losses, prevention of epidemics, and disease control. Detailed study of the representative examples of plant diseases casuad by fungi and bacteria

UNIT III

Bioplastics and biopolymers: Microorganisms involved in synthesis of biodegradable plastics, other pigments, Biosensors: Development of biosensors to detect food contamination and environment pollution, Biodiversity: Structural, biochemical and molecular systematics, Numerical taxonomy. Magnitude and distribution of biodiversity.

UNIT IV

Biofertilizers, Genetic engineering of microbes for enhanced pesticide degradation Mechanisms of pesticide degradation by microbes. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low-grade ores.

Practical

Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Detection of food-borne pathogens, pesticide degradation. Demonstration of biogas production. Production of biocontrol agents.

Suggested Readings

Alexander M. 1977. *Soil Microbiolog*y. John Wiley.

Hawker LE & Linton AH. 1989. *Microorganisms Function, Form and Environmen*t. 2 nd Ed. Edward Arnold.

James M Jaq 1987. *Modern Food Microbiolog*y. CBS.

Paul EA. 2007. *Soil Microbiology, Ecology and Biochemistr*y. 3 rd Ed Academic Press.

Stanbury PF & Whitaker A. 1987. *Principles of Fermentation Technology.*Pergamon Press.

Sylvia DM, Fuhrmann JJ, Hartlly PT & Zuberer D. 2005. *Principles and Applications of Soil Microbiolog*y. 2 nd Ed. Pearson Prentice Hall Edu.

11.MICRO 511 BIOFERTILIZER TECHNOLOGY 1+1

Objective

To familiarize the students and farmers with mass scale production of different agriculturally important microorganisms which are being used as biofertilizers for maintaining the soil and plant health for sustaining crop productivity and their importance in organic farming.

Theory

UNIT I

Different agriculturally important beneficial microorganisms – free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including cyanobacteria, taxonomic classification, nodule formation, competitiveness and quantification of N2 fixed.

UNIT II

Different agriculturally important beneficial microorganisms – phosphate solubilizing bacteria and fungi, including mycorrhiza.

UNIT III

Different agriculturally important beneficial microorganisms – plant growth promoting rhizobacteria.

UNIT IV

Different agriculturally important beneficial microorganisms – Biocontrol microbial inoculants.

UNIT V

Different agriculturally important beneficial microorganisms for recycling of organic waste and compositing, bioremediators and other related microbes.

UNIT VI

Different agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil & plant health, mass scale production and quality control of bio inoculants. Biofertilizer inoculation and microbial communities in the soil.

Practical

Isolations of symbiotic, asymbiotic, associative nitrogen fixating bacteria.Development and production of efficient microorganisms, Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc, Bioinoculant production and quality control

Suggested Readings

Alexander M. 1977. *Soil Microbiolog*y. John Wiley.
Bergerson FJ. 1980. *Methods for Evaluating Biological Nitrogen Fixation.*John Wiley & Sons.
Sylvia DM, Fuhrmann JJ, Hartlly PT & Zuberer D. 2005. *Principles andApplications of Soil Microbiology.* 2 nd Ed. Pearson Prentice Hall Edu.
van Elsas JD, Trevors JT & Wellington EMH. 1997. *Modern Soil Microbiolog*y. CRC Press.

12.MICRO 512 CYANOBACTERIAL AND ALGAL BIOTECHNOLOGY 1+1

Objective

To teach students about this upcoming fascinating field of microbes develoed at a faster pace, mainly due to photoautotrophic nature of Cyanobacteria, their ability to survive under a variety of habitats and wide diversity of thallus structure and functions. Their importance for mankind is enormous including their role as biofertilizers, nutraceuticals, experimental models, dyes, biofuels and a variety of biochemicals.
regarding structure, molecular evolution and properties of cyanobacteria and algae.

Theory

UNIT I

*Introduction to Cyanobacteria and alga*e. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of Cyanobacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes.

UNIT II

Algal pigments, storage products, carbon metabolism, photosynthesis.Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

UNIT III

Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes etc) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology, sustainable aquaculture. Ecology of algae- distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism.

UNIT IV

Algae in pollution - as pollution indicators, eutrophication agents and role in Bioremediation.Cyanobacterial and algal toxins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture – biofertilizers & algalization; soil conditioners; reclamation of problem soils.

Practicals

Isolation and identification of different groups of algae, media preparation for cyanobacteria, cyanobacterial pigment isolation and quantification. Algal symbiosis, *Azolla*; multiplication of *Azolla*, Bioformulation of cyanobacteria and other algae. Mass multiplication of algal inoculum

Suggested Readings

Ahluwalia AS. 2003. *Phycology: Principles, Processes and Application*s. Daya Publ.
Barsanti L & Gualtieri P. 2006. *Algae: Anatomy, Biochemistry and Biotechnology*. Taylor & Francis, CRC Press.
Carr NG & Whitton BA. 1982. *The Biology of Cyanobacteri*a. Blackwell.

Herrero A & Flores E. 2008. *The Cyanobacteria Molecular Biology,Genomics and Evolutio*n. Calster Academic Press
Kumar HD. 2005. *Introductory Phycology.* East West Press.
Linda E Graham & Lee W Wilcox. 2000. *Alga*e. Prentice Hall.
Robert A Andersen. 2005. *Algal Culturing Techniques.* Academic Press.
Venkataraman LV & Becker EW. 1985. *Biotechnology and Utilization of Algae: the Indian Experienc*e. DST.

List of Journals

- Advances in Microbial Physiology
- Annual Review of Genetics/Biochemistry
- Annual Review of Microbiology
- Applied and Environmental Microbiology
- Biology and Fertility Soils
- Indian Journal of Microbiology
- Journal of Bacteriology
- Journal of Basic Microbiology
- Microbiology and Molecular Biology Reviews
- Nature/Science/EMBO Journal
- Reviews in Microbiology and Biotechnology
- Soil Biology and Biochemistry
- Trends in Biotechnology
- Trends in Microbiology
- Trends in Plant Sciences

e-Resources

Books

- http://www.aw-bc.com/microplace/
- http://www.personal.psu.edu/jel5/micro/index.htm
- http://microbiology.ucsc.edu/

Details of sites related to Microbiology

- http://www.suite101.com/links.cfm/microbiology
- http://www.microbeworld.org/resources/links.aspx
- http://www.asm.org/
- http://www.microbiologyiworld.com/
- http://www.sciencemag.org/cgi/collection
- http://www.latrobe.edu.au/microbiology/links
- www.uwstout.edu/lib/subjects/microbi
- http://www.aemtek.com

Journal related to Microbiology

- http://www.fems-microbiology.org/website/nl/default.asp
- http://www.blackwellpublishing.com/journal
- http://www.springer.com/
- http://www.e-journals.org/microbiology/
- http://pubs.nrc-cnrc.gc.ca/
- http://www.elsevier.com/
- http://www.academicjournals.org/ajmr/
- http://www.horizonpress.com/gateway/journals.html
- http://www.scielo.br/bjm
- http://www.jmb.or.kr/

Latest in microbiology- Microbiology News

- http://microbiologybytes.wordpress.com/

• http://www.topix.net/science/microbiolog

Suggested Broad Topics for Master's and Doctoral Research

Molecular Microbiology

• Microbial diversity
• Meta genomics
• Improvement of beneficial microorganisms
(Nitrogen fixers, Phosphate solubilizers etc.)

Environmental Microbiology

• Biocontrol
• PGPR, Termite control, Pathogenic fungi control

Biofuels

•Biogas, alcohol production

Bioremediation

•Waste management, Bioremediation of industrial effluents and agrochemicals
•Composting

Microbial Biotechnology

• Biofertilizers
(Nitrogen fixers, Phosphate solubilizers, PGPR, BGA, composting etc)
• Secondary metabolites including industrially important enzymes, amino acids
• Citric acid and lactic acid fermentations

Food Microbiology

• Improvenment and industrial exploitation of microorganisms
• Fermented foods

VIII AGRICULTURAL ECONOMICS

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	Credits
AG ECON 501*	MICRO ECONOMIC THEORY AND APPLICATIONS	2+0
AG ECON 502*	MACRO ECONOMICS AND POLICY	2+0
AG ECON 503	EVOLUTION OF ECONOMIC THOUGHT	1+0
AG ECON 504*	AGRICULTURAL PRODUCTION ECONOMICS	1+1
AG ECON 505	AGRICULTURAL MARKETING AND PRICE ANALYSIS	2+1
AG ECON 506*	RESEARCH METHODOLOGY FOR SOCIAL SCIENCES	1+1
AG ECON 507*	ECONOMETRICS	2+1
AG ECON 508	LINEAR PROGRAMMING	1+1
AG ECON 509*	AGRICULTURAL FINANCE AND PROJECT MANAGEMENT	2+1
AG ECON 510	INTERNATIONAL ECONOMICS	1+1
AG ECON 511	AGRICULTURAL DEVELOPMENT POLICY ANALYSIS	2+0
AG ECON 512	INSTITUTIONAL ECONOMICS	1+0
AG ECON 513	NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS	1+1
AG ECON 514	INTELLECTUAL PROPERTY MANAGEMENT	1+0
AG ECON 515	RURAL MARKETING	2+0
AG ECON 519***	GENERAL ECONOMICS	2+0
AG ECON 591	MASTER'S SEMINAR	0+1
AG ECON 599	MASTER'S RESEARCH	20
	Ph.D COURSES	
AGECON 601**	ADVANCED MICRO ECONOMIC ANALYSIS	1+1
AGECON 602**	ADVANCED MACRO ECONOMIC ANALYSIS	2+0
AG ECON 603**	ADVANCED ECONOMETRICS	2+1
AG ECON 604	ADVANCED PRODUCTION ECONOMICS	2+1
AG ECON 605	QUANTITATIVE DEVELOPMENT POLICY ANALYSIS	1+1
AG ECON 606**	ADVANCED AGRICULTURAL MARKETING AND PRICE ANALYSIS	2+1
AG ECON 607	COMMODITY FUTURES TRADING	2+0
AG ECON 608	NATURAL RESOURCE MANAGEMENT	1+1
AG ECON 609	ENVIRONMENTAL ECONOMICS	2+0
AG ECON 691	DOCTORAL SEMINAR I	0+1
AG ECON 692	DOCTORAL SEMINAR II	0+1
AG ECON 699	DOCTORAL RESEARCH	45

*Compulsory for Master's Programme

** Compulsory for Doctoral Programme

*** Remedial course for Agrl Statistics

1. AG ECON 501 MICRO ECONOMIC THEORY AND APPLICATIONS 2+0

Objective

This course is intended to provide an overview of microeconomic theory and its applications. The course starts with the theory of consumer behaviour consisting of consumer's utility maximization problem and demand theory. It intends to provide fundamental concepts and models in the theory of production and costs and sets out to provide a basic understanding of price and / or output determination under different types of market structures including factor markets. This course will also expose the students to the theory of general equilibrium and welfare economics.

Theory

UNIT I

Theory of Consumer Behaviour - Cardinal Utility Approach - Ordinal Utility Approach – Income effect and substitution effect – Applications of Indifference curve approach - Revealed Preference Hypothesis – Consumer surplus - Derivation of Demand curve – Elasti city of demand.

UNIT II

Theory of Production - Production functions – Returns to scale and economies of scale – Technical progress – Theory of Costs – Cost curves– Profit maximization and cost minimization – Derivation of supply curve – Law of Supply – Producers' surplus.

UNIT III

Market Equilibrium - Behavior of Firms in Competitive Markets – Perfect Competition- Effect of Taxation and Subsidies on market equilibrium - Monopoly-Monopolistic - Oligopoly- Theory of Factor Markets.

UNIT IV

General Equilibrium Theory - Welfare Economics - Pareto Optimality – Social welfare criteria - Social Welfare functions.

Suggested Readings:

David M Kreps 1990. *A Course in Microeconomic Theory*. Princeton University Press.

Dewitt KK. 2002. *Modern Economic Theory*. Sultan Chand & Co.

Henderson JM & Quandt RE. 2000. *Microeconomic Theory: A Mathematical Approach*. McGraw-Hill.

Koutsoyiannis A. 2003. Modern Microeconomics. The Macmillan Press.

Silberberg E & Suen W. 2001. *The Structure of Economics – A Mathematical Analysis*. McGraw-Hill.

Varian Hal R. 1999. *Intermediate Microeconomics*. Affiliated East-West Press.

2.AG ECON 502 MACRO ECONOMICS AND POLICY 2+0

Objective

Macro economics and Policy course is intended to expose the students to macroeconomic concepts and theory, the application of the macro economic theory, and implication of the macroeconomic policies.

Theory

UNIT I

Nature and Scope of Macro Economics - Methodology and Keynesian Concepts National Income - Concepts and measurement- Classical theory of Employment and Say's Law-Modern theory of Employment and Effective Demand.

UNIT II

Consumption function- Investment and savings - Concept of Multiplier and Accelerator - Output and Employment - Rate of interest - Classical, Neo classicaland Keynesian version- Classical theory Vs Keynesian theory – Unemployment and Full employment.

UNIT III

Money and classical theories of Money and Price - Keynesian theory of money and Friedman Restatement theory of money - Supply of Money - Demand for Money - Inflation: Nature, Effects and control.

UNIT IV

IS & LM frame work - General Equilibrium of product and money markets - Monetary policy - Fiscal policy- Effectiveness of Monetary and Fiscal policy - Central banking.

UNIT V

Business cycles - Balance of Payment - Foreign Exchange Rate determination.

Suggested Readings:

Ahuja HL. 2007. *Macroeconomics: Theory and Policy*. S. Chand & Co.

Eugene A Diulio 2006. *Macroeconomics*. 4th Ed. Schaums' Outlines.

Gardner Ackely 1987. *Macro Economic: Theory and Policy*. Collier Macmillan.

Dornbusch. 2006. *Macroeconomics*. McGraw Hill Publication

3. AG ECON 503 EVOLUTION OF ECONOMIC THOUGHT 1+0

Objective

To introduce the students to the evolution of economic thought over a period of time, the background of emanation of thoughts and approaches, as acts of balancing and counter balancing events and criticisms. The course will also in a comprehensive way help the students to know and appreciate the contributions of the Galaxy of Economists.

Theory

UNIT 1

Approaches for the study of history of economic thought – Absolutist vs. Relativist approaches – Evolution of Economic Thought vs. Economic History. Ancient economic thought – medieval economic thought – mercantilism – physiocracy – Forerunners of Classical Political Economy.

UNIT II

Development of Classical Thoughts (Adam Smith, Robert Malthus and David Ricardo) – Critics of Classical Thoughts- Socialist critics – Socialist and MarxianEconomic Ideas – Austrian School of Thought – Origins of Formal

Microeconomic Analysis – William Stanley Jevons, Cournot and Dupuit.

UNIT III

The birth of neoclassical economic thought – Marshall and Walras – General Equilibrium Theory - Welfare Theory – Keynesian economics.

UNIT IV

The Era of globalization – Experiences of developing world - Rigidity of the past vs. emerging realism – The changing path of international Institutions to economic growth and development approaches.

UNIT V

Economic Thought in India – Naoroji and Gokhale – Gandhian Economics - Economic thought of independent India – Nehru's economic philosophy - Experiences of the Structural adjustment programmes of the post liberalization era.

Suggested Readings

Blaug M. 1964. *Economic Theory in Retrospect*. Heineman.

Blaug M. 1986. *Economic History and the History of Economic Thought*.Wheatsheaf Books, Brighton.
Ekelund RB & Hebert RF. 1975. *A History of Economic Theory and Methods*. McGraw-Hill.
John Mills A. 2002. *Critical History of Economics: Missed Opportunities*. Palgrave Macmillan.
Screpanti E & Zamagni S. 1995. *An Outline of the History of Economic Thought.* Clarendon Press, Oxford.

4.AG ECON 504 AGRICULTURAL PRODUCTION ECONOMICS 1+1

Objective

To expose the students to the concept, significance and uses of agricultural production economics.

Theory

UNIT I

Nature, scope and significance of agricultural production economics- Agricultural Production processes, character and dimensions-spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions.

UNIT II

Factors of production, classification, interdependence, and factor substitution - Determination of optimal levels of production and factor application –Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.

UNIT III

Cost functions and cost curves, components, and cost minimization –Duality theory – cost and production functions and its applications -Derivation of firm's input demand and output supply functions -Economies and diseconomies of scale.

UNIT IV

Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement -Nature and sources of risk, modeling and coping strategies.

Practical

Different forms of production functions - specification, estimation and interpretation of production functions – returns to scale, factor shares, elasticity of production - physical optima-economic optima-least cost combination- optimal product choice- cost function estimation, interpretation-estimation of yield gap -incorporation of technology in production functions- measuring returns to scalerisk analysis through linear programming.

Suggested Readings

Beattie BR & Taylor CR. 1985. *The Economics of Production*. John Wiley & Sons.
Doll JP & Frank O. 1978. *Production Economics - Theory and Applications*. John Wiley & Sons.
Gardner BL & Rausser GC. 2001. *Handbook of Agricultural Economics*. Vol. I. *Agricultural Production*. Elsevier.
Heady EO. *Economics of Agricultural Production and Resource Use*. Prentice- Hall.
Sankayan PL. 1983. *Introduction to Farm Management*. Tata Mc Graw Hill.

5.AG ECON 505 AGRICULTURAL MARKETING AND PRICE ANALYSIS 2+1

Objective

To impart adequate knowledge and analytical skills in the field of agriculturalmarketing issues, and enhance expertise in improving the performance of the marketing institutions and the players in marketing of agricultural commodities.

Theory

UNIT I

Review of Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration - Integration over space, time and form-Vertical coordination.

UNIT II

Marketing Co-operatives – APMC Regulated Markets - Direct marketing, Contract farming and Retailing - Supply Chain Management - State trading, Warehousingand other Government agencies -Performance and Strategies – Market infrastructure needs, performance and Government role - Value Chain Finance.

UNIT III

Role of Information Technology and telecommunication in marketing of agricultural commodities - Market research-Market information service - electronic auctions (e-bay), e-Chaupals, Agmarket and Domestic and Export market Intelligence Cell (DEMIC) – Market extension.

UNIT IV

Spatial and temporal price relationship – price forecasting – time series analysis – time series models – spectral analysis. Price policy and economic development – non-price instruments.

UNIT V

Theory of storage - Introduction to Commodities markets and future trading - Basics of commodity futures - Operation Mechanism of Commodity markets – Price discovery - Hedging and Basis - Fundamental analysis - Technical Analysis - Role of Government in promoting commodity trading and regulatory measures.

Practical

Supply and demand elasticities in relation to problems in agricultural marketing. Price spread and marketing efficiency analysis. Marketing structure analysis through concentration ratios. Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products. Chain Analysis - quantitative estimation of supply chain efficiency - Market Intelligence – Characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports – commodity outlook - Technical Analysis for important agricultural commodities - Fundamental Analysis for important agricultural commodities - Presentation of the survey results and wrap-up discussion.

Suggested Readings

Purecell WD & Koontz SR. 1999. *Agricultural Futures and Options: Principles and Strategies*. 2nd Ed. Prentice-Hall.

Rhodes VJ. 1978. *The Agricultural Marketing System*. Grid Publ., Ohio.

Shepherd SG & Gene AF. 1982. *Marketing Farm Products*. Iowa State Univ.Press.

Singhal AK. 1986. *Agricultural Marketing in India*. Annual Publ., New Delhi.

6. AG ECON 506 RESEARCH METHODOLOGY FOR SOCIAL SCIENCES 1+1

Objective

To expose the students to research methodology used in social sciences. The focus will be on providing knowledge related to research process, data collection and data analysis etc.

Theory

UNIT I

Importance and scope of research in agricultural economics. Types of research - Fundamental vs. Applied. Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process.

UNIT II

Hypothesis – meaning - characteristics - types of hypothesis – review of literature – setting of Course Objective and hypotheses - testing of hypothesis.

UNIT III

Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose. Project proposals – contents and scope – different types of projects to meet different needs – trade-off between scope and cost of the study. Research design and techniques – Types of research design.

UNIT IV

Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule – problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey – Reconnaissance survey and Pre testing.

UNIT V

Coding editing – tabulation – validation of data. Tools of analysis – data processing. Interpretation of results – Preparing research report / thesis – Universal procedures for preparation of bibliography – writing of research articles.

Practical

Exercises in problem identification. Project proposals – contents and scope. Formulation of Objective and hypotheses. Assessment of data needs – sources of data – methods of collection of data. Methods of sampling – criteria to choose – discussion on sampling under different situations. Scaling Techniques –measurement of scales. Preparation of interview schedule - Field testing. Method of conducting survey. Exercise on coding, editing, tabulation and validation of data. Preparing for data entry into computer. Hypothesis testing – Parametric and Non-Parametric Tests. Exercises on format for Thesis / Report writing.Presentation of the results.

Suggested Readings

Black TR. 1993. *Evaluating Social Science Research - An Introduction***.** SAGE Publ.

Creswell JW. 1999. *Research Design - Qualitative and Quantitative Approaches.* SAGE Publ.

Dhondyal SP. 1997. *Research Methodology in Social Sciences and Essentials of Thesis Writing*. Amman Publ. House, New Delhi.

Kothari CR. 2004. *Research Methodology - Methods and Techniques***.** Wishwa Prakashan, Chennai.

Rao KV. 1993. *Research Methodology in Commerce and Management***.** Sterling Publ., New Delhi.
Singh AK. 1993. *Tests, Measurements and Research Methods in Behavioural Sciences***.** Tata McGraw-Hill.
Venkatasubramanian V. 1999. *Introduction to Research Methodology in Agricultural and Biological Sciences*. SAGE Publ.

7. AG ECON 507 ECONOMETRICS 2+1

Objective

The Course Objective of the course is to impart knowledge on econometric tools to the students of agricultural economics. Training in econometrics will help the student to analyze the economic problem by applying quantitative techniques.

Theory

UNIT I

Introduction – relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis.

UNIT II

Basic two variable regression - assumptions estimation and interpretationapproaches to estimation - OLS, MLE and their properties - extensions to multi variable models-multiple regression estimation and interpretation.

UNIT III

Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches - model misspecification.

UNIT IV

Use of dummy variables-limited dependent variables – specification, estimation and interpretation.

UNIT V

Simultaneous equation models – structural equations - reduced form equations - identification and approaches to estimation.

Practical

Single equation two variable model specification and estimation – hypothesis testing-transformations of functional forms and OLS application-estimation of multiple regression model - hypothesis testing - testing and correcting specification errors - testing and managing Multicollinearity - testing and managing heteroscedasticity - testing and managing autocorrelation - estimation of regressions with dummy variables - estimation of regression with limited dependent variable - identification of equations in simultaneous equation systems.

Suggested Readings

Gujarati DN. 2003. *Basic Econometrics*. McGraw Hill.
Johnson AG Jr., Johnson MB & Buse RC. 1990. *Econometrics - Basic and Applied.* MacMillan.
Kelejan HH & Oates WE. 1994.*Introduction to Econometrics Principles and Applications*. Harper and Row Publ.
Koutsoyianis A. 1997. *Theory of Econometrics*. Barner & Noble.
Maddala GS. 1992. *Introduction to Econometrics*. MacMillan.
Maddala GS. 1997. *Econometrics.* McGraw Hill.
Pindyck RS & Rubinfeld DL. 1990. *Econometrics Models and Econometric Forecasts*. McGraw Hill.

8.AG ECON 508 LINEAR PROGRAMMING 1+1

Objective

To impart knowledge of Linear programming techniques.

Theory

UNIT I

Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

UNIT II

Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non farm problems as linear programming models and solutions.

UNIT III

Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

UNIT IV

Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programme.

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

Suggested Readings

Dorfman R. 1996. *Linear Programming & Economic Analysis*. McGraw Hill.

Loomba NP.2006. *Linear Programming*. Tata McGraw Hill.

Shenoy G. 1989. *Linear Programming-Principles & Applications*. Wiley Eastern Publ.

Vaserstein. 2006. *Introduction to Linear Programming*. Pearson Education Publication

9. AG ECON 509 AGRICULTURAL FINANCE AND PROJECT MANAGEMENT 2+1

Objective

The Course Objective of the course is to impart knowledge on issues related to lending to priority sector credit management and financial risk management. The course would bring in the various appraisal techniques in project - investment of agricultural projects.

Theory

UNIT I

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.

UNIT II

Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation ofTechnical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

UNIT III

Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/firm.

UNIT IV

Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money – Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Net work Techniques – PERT and CPM.

UNIT V

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes – yield loss and weather based insurance and their applications.

Practical

Development of Rural Institutional Lending - Branch expansion, demand and supply of institutional agricultural credit and Over dues and Loan waiving- : An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions, Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through

financial statements, Performance of Micro Financing Institutions - NGO's and Self-Help Groups, Identification and formulation of investment projects, Project appraisal techniques – Undiscounted Measures and their limitations. Project appraisal techniques – Discounted Measures, Network techniques – PERT and CPM for project management, Case Study Analysis of an Agricultural project, Financial Risk and risk management strategies – crop insurance schemes, Financial instruments and methods – E banking, Kisan Cards and core banking.

Suggested Readings:

Dhubashi PR. 1986. *Policy and Performance - Agricultural and Rural Development in Post Independent India*. Sage Publ.

Gittinger JP 1982. *Economic Analysis of Agricultural Projects***.** The Johns Hopkins Univ. Press.

Gupta SC. 1987. *Development Banking for Rural Development*. Deep & Deep Publ.

Little IMD & Mirlees JA. 1974. *Project Appraisal and Planning for Developing Countries***.** Oxford & IBH Publ.

Muniraj R. 1987. *Farm Finance for Development*. Oxford & IBH Publ.

10.AG ECON 510 INTERNATIONAL ECONOMICS 1+1

Objective

The expected outcome of this course will be creating awareness among thestudents about the role of International Economics on National welfare.

Theory

UNIT I

Scope and Significance of International Economics - The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) – Equilibrium in a Simple Open Economy - Possibility of World Trade - Trade gains and Trade Equilibrium.

UNIT II

Tariff, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints- The Case of Small Country and Large Country Case.

UNIT III

Ricardian Model of Trade- Specific Factors Model- Heckscher - Ohlin Model - Trade Creation and Trade Diversion – Offer Curve - Export Supply Elasticity and Import Demand Elasticity - Comparative Advantage and Absolute Advantage.

UNIT IV

Official Exchange Rate and Shadow Exchange Rate - Walra's Law and Terms of Trade – Trade Blocks.

UNIT V

IMF, World Bank, IDA, IFC, ADB – International Trade agreements – Uruguay Round – GATT – WTO.

Practical

Producer's Surplus, Consumer's Surplus, National Welfare under Autarky and Free Trade Equilibrium with small and large country assumption- Estimation of Trade Gains- Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC- Estimation of Offer Curve Elasticity- Estimation of Effect of Tariff, Export Subsidy, Producer Subsidy, Import Quota and Export Voluntary Restraintson National Welfare- Estimation of Ricardian Model - Estimation of Effect of Trade under Specific Factor Model- Estimation of trade Equilibrium under Heckscher -Ohlin model - Trade Creation and Diversion.

Suggested Readings :

Apple Yard DR & Field AJ Jr. 1995. *International Economics - Trade, Theory and Policy*. Irwin, Chicago.

Cherunilam F. 1998. *International Economics*. Tata McGraw Hill.

Krugman PR & Obstfeld M. 2000. *International Economics – Theory and Policy*. Addison-Wesley.

11.AG ECON 511: AGRICULTURAL DEVELOPMENT AND POLICIES 2+0

Objectives

• to provide orientation to the students regarding the concepts and measures of economic development

• to provide orientation on theories of economic growth and relevance of theories in developing countries.

• to make them to understand the agricultural policies and its effect on sustainable agricultural development

• to make them to understand the globalization and its impact on agricultural development.

Theory

UNIT I

Development Economics – Scope and Importance - Economic development and economic growth - divergence in concept and approach - Indicators and Measurement of Economic Development – GNP as a measure of economic growth – New Measures of Welfare – NEW and MEW – PQLI – HDI – Green GNP - Criteria for under development – Obstacles to economic development – Economic and Non-Economic factors of economic growth.

UNIT II

Economic development – meaning, stages of economic development, determinants of economic growth. Theories of economic growth – Ricardian growth model – The Harrod – Domar Model – The Neo classical Model of Growth – The Kaldor Model – Optimal Economic Growth – Recent Experiences of developing country economies in transition – Role of state in economic development – Government measures to promote economic development. Introduction to development
planning.

UNIT III

Role of agriculture in economic / rural development – theories of agricultural development – Population and food supply - need for sound agricultural policies – resource policies – credit policies – input and product marketing policies – price policies.

UNIT IV

Development issues, poverty, inequality, unemployment and environmental degradation – Models of Agricultural Development – Induced Innovation Model - policy options for sustainable agricultural development.

UNIT V

Globalization and the relevance of development policy analysis – The dilemma of free trade? – Free trade versus Protectionism- Arguments for protection. Arguments against protection. Role of protection in Developing Countries. WTO – Agreement on Agriculture - Contradictions of free trade - proponents and opponents policies in vulnerable sectors like agriculture – Lessons for developing countries.

Suggested Readings

Chakaravathi RM. 1986. *Under Development and Choices in Agriculture*. Heritage Publ.,
New Delhi.

Diwett KK. 2002. *Modern Economic Theory***.** S. Chand & Co. 49

Eicher KC & Staatz JM. 1998. *International Agricultural Development*. Johns Hopkins Univ. Press.

Frank E. 1992. *Agricultural Polices in Developing Countries*. Cambridge Univ. Press.

Ghatak S & Ingersent K. 1984. *Agriculture and Economic Development*. Select Book Service Syndicate, New Delhi.

Jhingan ML. 1998. *The Economics of Development and Planning*. Vrinda Publ.

Jules PN. 1995. *Regenerating Agriculture – Polices and Practice for Sustainability and Self Reliance*. Vikas Publ. House.

Naqvi SNH. 2002. *Development Economics – Nature and Significance*. Sage Publ.

12.AG ECON 512 INSTITUTIONAL ECONOMICS 1+0

Objective

The course exposes the students to the institutional problems and remedies.

Theory

UNIT I

Old and New Institutional Economics - Institutional Economics Vs Neo- classical Economics. Definition of institutions – Distinction between institutions and organizations - Institutional evolution

UNIT II

Institutional change and economic performance - national and international economic institutions. Transaction cost economics – Transaction costs and the allocation of

resources. Transaction costs and efficiency. Asymmetric information - Moral hazard and Principal-Agent problem.

UNIT III

Free rider problem – path dependency – Interlinked transactions. Collective action and the elimination of free-rider problem - The logic of collective action and its role in reducing free rider problem – theory of Groups. Rent seeking – interest groups and policy formulation.

UNIT IV

Economic analysis of property rights- property rights regimes – private property –State Property - Common property Resources (CPRs) – public goods and club goods.

UNIT V

Special features of institutional arrangements in agriculture – Transaction costs in agriculture - Case Studies - Theories of agrarian institutions - tenancy institutions.

Suggested Readings

Barzel, Y. 1990. *Economic Analysis of Property Rights*. Cambridge Univ. Press.

Bhardhan P. (Ed.). 1989. *The Economic Theory of Agrarian Institutions*. Clarendon Press, Oxford.

Bromley DW. 1989. *Economic Interests and Institutions: The Conceptual Foundations of Public Policy*. Basil Blackwell, Cambridge.

Eggertsson T. 1990. *Economic Behaviour and Institutions*. Cambridge Univ. Press.

Greif A. 2006. *Institutions and the Path to the Modern Economy: Lessons from Medieval Trade (Political Economy of Institutions & Decisions).* Cambridge Univ. Press.

Neelakandan S. 1992. *New Institutional Economics and Agrarian Change – A Primer*. Indian Economic Association Trust for Research and Development, New Delhi.

North DC. 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge Univ. Press.

Ostrom E. 1990. *Governing the Commons: The Evolutions of Institutions for Collective Actions.* Cambridge Univ. Press.

13.AG ECON 513 NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS 1+1

Objectives

• To introduce economics principles related to natural resource and environmental economics

• To explore the concept of efficiency and the efficient allocation of natural resources

• To understand the economics of why environmental problems occur.

• To explore the concept of efficiency and the efficient allocation of pollution control and pollution prevention decisions.

• To understand the environmental policy issues and alternative instruments of environmental policies

Theory

UNIT I

Concepts, Classification and Problems of Natural Resource Economics – Economy - Environment interaction – The Material Balance principle, Entropy law- Resources Scarcity - Limits to Growth - Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity – scarcity indices - Resource Scarcity and Technical Change.

UNIT II

Theory of optimal extraction renewable resources –economic models of oil extraction-efficiency - time path of prices and extraction - Hotelling's rule, Solow-Harwick's Rule. Theory of optimal extraction exhaustible resources – economic models of forestry and fishery.

UNIT III

Efficiency and markets – market failures - externalities – types - property rights – transaction costs – Coase's theorem and its critique - public goods – common property and open access resource management - Collective action.

UNIT IV

Environmental perspectives - biocentrism, sustainability, anthropocentrism - Environmental problems and quality of environment - Sources and types of pollution - air, water, solid waste, land degradation – environmental and economic impacts - Economics of pollution control - efficient reduction in environmental pollution.

UNIT V

Environmental regulation – economic instruments - pollution charges – Pigovian tax - tradable permits – indirect instruments - environmental legislations in India.

UNIT VI

Concept of sustainable development - Economic Perspective - Indicators of sustainability Relation between development and environment stress- Environmental Kuznet's curve Environmental Accounting – resource accounting methods - International Environmental Issues – climate change – likely impacts - mitigation efforts and international treaties.

Practical

Exhaustible resource management –optimum rate of oil extraction. Renewable resource management – optimum harvest of Forestry/fishery. Exercise on pollution abatement – I. Exercise on pollution abatement –II. Concepts in valuing the environment. Taxonomy of valuation techniques. Productivity change method – substitute cost method - Hedonic price method - Travel cost method –Contingent valuation methods. Discount rate in natural resource management. Environment impact assessment Visit to Pollution Control Board.

Suggested Readings

Ahmad Y, El Serafy S & Lutz E. (Eds.). 1989.Environmental Accounting for Sustainable Development. World Bank.

Freeman AM. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future Press, Baltimore.

Hackett SC. 2001. *Environmental and Natural Resource Economics: Theory, Policy, and the Sustainable Society*. M. E. Sharpe, Armonk, NY.

Hartwick JM & Olewiler ND. 1998. *The Economics of Natural Resource Use*. 2nd Ed. Addison-Wesley Educational Publ.

Kerr JM, Marothia DK, Katar Singh, Ramasamy C & Bentley WR. 1997. *Natural Resource Economics: Theory and Applications in India.* Oxford & IBH.

Kolstad CD. 2000. Environmental Economics. Oxford Univ. Press.

Pearce DW & Turner K. 1990. *Economics of Natural Resources and the Environment*. John Hopkins Univ. Press.

Prato T. 1998. *Natural Resource and Environmental Economics*. Iowa State Univ. Press.

Sankar U. 2001. Environmental Economics. Oxford Univ. Press.

Sengupta R. 2000. *Ecology and Economy, an Indian Perspective*. Oxford Univ. Press.

Tietenberg T. 2003. *Environmental and Natural Resource Economics*. 6th Ed. Addison Wesley.

14.AG ECON 514 INTELLECTUAL PROPERTY MANAGEMENT 1+0

Objective

The Course Objective of the course is to create awareness about intellectual property rights in agriculture. The course deals with management of patents, trademark, geographical indications, copy rights, designs, plant variety protection and biodiversity protection. The students will be taught on the Marketing and Commercialization of Intellectual Properties.

Theory

UNIT I

World Trade Organization- Agreement on Agriculture (AoA) and Intellectual Property Rights (IPR) - Importance of Intellectual Property Management - IPR and Economic growth- IPR and Bio diversity -Major areas of concern in Intellectual Property Management -Technology Transfer and Commercialization-Forms of different Intellectual Properties generated by agricultural research.

UNIT II

Discovery *versus* Invention - Patentability of Biological Inventions - Method of Agriculture and Horticulture- procedure for patent protection: Preparatory work. Record keeping, writing a patent document, filing the patent document -Types of patent application-patent application under the Patent cooperation treaty (PCT).

UNIT III

Plant genetic resources -Importance and conservation - Sui Generic System –Plant Varieties Protection and Farmers Rights Act- Registration of Extant varieties - Registration and protection of New Varieties / Hybrids / Essentially Derived Varieties - Dispute prevention and settlement -Farmers' Rights.

UNIT IV

Trademark- Geographical Indications of Goods and Commodities – Copy rights- Designs – Biodiversity Protection.

UNIT V

Procedures for commercialization of technology - Valuation, Costs and Pricing of Technology- Licensing and implementation of Intellectual Properties- Procedures for commercialization – Exclusive and non exclusive marketing rights-Research Exemption and benefit sharing .

Suggested Readings:

Ganguli P. 2001. *Intellectual Property Rights –Unleashing the KnowledgeEconomy*. Tata McGraw Hill.

Gupta AK. 2003. *Rewarding Conservation of Biological and Genetic Resources and Associated Traditional Knowledge and Contemporary Grass Roots Creativity*. Indian Institute of Management, Ahmedabad.

Khan SA & Mashelkar R. 2004. *Intellectual Property and Competitive Strategies in the 21st Century*. Kluwer Law International, The Hague.

15.AG ECON 515 RURAL MARKETING 2+0

Objective

To provide understanding regarding issues in rural markets like marketing environment, consumer behaviour, distribution channels, marketing strategies, etc.

Theory

UNIT I

Concept and scope of rural marketing, nature and characteristics of rural markets,potential of rural markets in India.

UNIT II

Environmental factors - socio-cultural, economic and other environmental factors affecting rural marketing.

UNIT III

Rural consumer's behaviour - behavior of rural consumers and farmers; buyer characteristics and buying behaviour; Rural v/s urban markets.

UNIT IV

Rural marketing strategy - Marketing of consumer durable and non-durable goods and services in the rural markets with special reference to product planning; product mix, pricing Course Objective, pricing policy and pricing strategy.

UNIT V

Product promotion - Media planning, planning of distribution channels, and organizing personal selling in rural market in India.

Suggested Readings

Krishnamacharyulu CSG & Ramakrishan L. 2002. *Rural Marketing.* Pearson Edu.

Ramaswamy VS & Nanakumari S. 2006. *Marketing Management.* 3rd Ed. MacMillan.

Singh AK & Pandey S. 2005. *Rural Marketing*. New Age.

Singh Sukhpal. 2004. *Rural Marketing*. Vikas Publ. House.

19. AG ECON 519 GENERAL ECONOMICS 2+0

Objective:

This course is intended to provide an overview of economic theory and its application to the beginners. This course starts with basic concepts and deals with consumption theory, Production theory , Factor pricing and product pricing. This course is offered as a remedial course to the students of the department of Agrl.Statistics.

Theory

Unit I

Basic Concepts : Definition, Nature and scope of Economics – Methods of Scientific Study – Micro and macro economics- Distinction, importance and limitations – Economics statics and Dynamics – importance and limitations- concept of equilibrium – economic systems.

Unit II

Consumption Theory : Assumptions of utility analysis – Cardinal and ordinal utility – Law of diminishing marginal utility - The proportionality rule- Demand – law of demand- Exceptions to the Law of demand- Indifference curves – properties- Consumer's equilibrium – Income effect and substitution effect .

Unit III

Production Theory – Scale of production- Advantage and disadvantage of small and large scale production – Laws of return- The production function – The law of variable proportion and returns to scale – laws of Return – The Isoquant- Isocost approach

Unit IV

Product Pricing and Factor Pricing – The nature of Cost- Concept of Revenue – Equilibrium of firm under perfect competition, monopoly and monopolistic competition – Assumptions and criticisms of the Marginal productivity theory of Distribution.

Suggested Reading :

1. Dewett K.K.,2002, *Modern economic Theory* , Sultan Chand & Co.

2. Seth M.L., 1983, *Principles of Economics* , Lakshmi CVerain Agrawal Publishers, Agra

3. Jhingan , M.L., 1986, *Micro Economic theory* , Konark Publishers Private Ltd, Delhi

Ph.D COURSES

1. AG ECON 601 ADVANCED MICRO ECONOMIC ANALYSIS 1+1

Objectives

The Course Objective of this course is to introduce the theoretical models and applications of microeconomic theory. In particular, the basic comparative statistical techniques and the more modern duality theory will be developed and applied to the models of maximization, unconstrained and constrained utility maximization, expenditure minimization, constrained profit maximization, and cost and expenditure minimization. These mathematical structures form the basic building blocks of neoclassical economics; this course will stress the development and application of these important models. We follow a calculus rather than a graphical approach to the theory. In the subsequent sections of the course, we provide a fairly rigorous exposure to price determination under different market situations, general equilibrium theory, causes and consequences of market failure and welfare economics including the theory of public choice.

Theory

UNIT I

Theory of consumer behaviour – Duality in consumer theory – expenditure function and indirect utility function - Measurement of Income Effect and Substitution Effect. Measurement of Changes in Consumers' Welfare – Consumer's Surplus, Compensating Variation and Equivalent Variation – Dynamic versions of demand functions – Integrability of demand functions. Demand

Models – Linear Expenditure System, Almost Ideal Demand System. Applications of consumer theory – Household model and time allocation – Labour supply decisions by households.

UNIT II

Perfect competition – Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly – Cournot model, Chamberlin model, Stackleberg solution.

UNIT III

General equilibrium theory – Conceptual overview - General equilibrium conditions with Production and Consumption. Existence, Uniqueness and Stability of general competitive equilibrium. Walrasian general equilibrium – Mathematical derivation of conditions for general equilibrium.

UNIT IV

Market failure - Incomplete markets - Asymmetric information – Principal-Agent problem, adverse selection and moral hazard. Externalities – Network externalities - Public goods – Optimal provision of public goods.

UNIT V

Welfare Economics - Concepts, problems, approaches and limitations of Welfare Economics, Pareto conditions of maximum welfare – Criteria for social welfare - Social Welfare functions, Social versus Private costs and benefits.

Practical

Problems in consumer utility maximization – Estimation of income and substitution effects; Estimation and comparison of Consumer's surplus, equivalent variation and compensating variation. Estimation of demand models – Derivation and estimation of labour supply equations from household models comparative static analysis in consumption. Advanced problem solving in price determination under perfect competition, monopoly, oligopoly and monopolistic competition. Game theory models.

Problems solving in General Equilibrium Theory and Welfare Economics. Problems in public goods provision.

Suggested Readings

Chiang AC. 1981. *Fundamental Methods of Mathematical Economics*. McGraw-Hill.
Henderson JM & Quandt RE. *Microeconomic Theory: A Mathematical Approach*. McGraw-Hill.
Koutsoyiannis A. 2003. Modern Microeconomics. The Macmillan Press.
Kreps DM. 1990. *A Course in Microeconomic Theory*. Princeton Univ. Press.
Silberberg E & Suen W. 2001. *The Structure of Economics - A Mathematical Analysis*. McGraw-Hill.
Varian HR. 1992. *Microeconomic Analysis*. WW Norton & Co.55
Varian HR. 1999. *Intermediate Microeconomics*. Affiliated East-West Press.

2.AG ECON 602 ADVANCED MACRO ECONOMICS ANALYSIS 2+0

Objective

Advanced macroeconomics course will be offered to PhD students of Agricultural Economics with the following Course Objective.

- to understand the macroeconomic theory
- to examine the macroeconomic Policy issues
- to analyze the macroeconomic Policy implications

Theory

UNIT I

Review of Macro Economics concepts-Comparative statistics- Keynesian theory-Consumption Function and Theories of Consumption -Saving Function and Theories of Saving.

UNIT II

Theories of Investment-Savings and Investment Equality - IS - LM Framework and its mand for and Supply of Money-Monetary Policy in the static model – Inflation.

UNIT III

Stagflation and Supply side Economics - Theory of Unemployment – Phillips Curve controversy - Inflation, Productivity and distribution - Fiscal policy: Effectiveness and Problems.

UNIT IV

Social Accounting Matrix Framework - General Equilibrium Analysis - Neo classical Macro Economics - Stochastic Macro Economics.

UNIT V

BOP & Adjustment Policies - Foreign Exchange Policy - Foreign sector : Capital and Current Account - Impact of WTO on Indian Economy - Impact of IMF & IBRD on Indian Economy - Review of Macro Economic Policies in India.

Suggested Readings

Diulio EA. 2006. *Macroeconomics*. 4th Ed. Schaums' Outlines.
Frogen RT. 1999. *Macro Economic: Theory and Policies*. 6th Ed. Prentice Hall.
Samuelson PA & Nordhaus WD. 2004. *Economics*. McGraw-Hill.
Shapiro E. 1989. Macro Economic Analysis. Galgotia Publ.

3. AG ECON 603 ADVANCED ECONOMETRICS 2+1

Objective

The Course Objective of the course is to impart knowledge on advanced econometric tools to the Research Scholars of agricultural economics. Training in advanced

econometrics will help the Research Scholars to analyze the economic problem by applying quantitative techniques.

Theory

UNIT I

Review of classical regression model – review of hypothesis testing – restrictions on parameters – single equation techniques.

UNIT II

Ordinary least squares – weighted least squares - generalized least squares – method of principal components – instrumental variables method – maximum 56 likelihood method - errors in variables, non-linearity and specification tests – non
spherical error terms.

UNIT III

Dummy variables - Qualitative and truncated dependent variables – limited dependent variables –LPM, probit and logit models, their multinomial extensions.

UNIT IV

Autoregressive distributed lag models – panel data fixed and random effects models and their extensions.

UNIT V

Simultaneous equation methods –identification – estimation by indirect least squares 2SLS, PIML, SURE, 3SLS.

Practical

Estimation of multiple regression model - GLS estimation methods – testing misspecification errors – Testing and Managing multicollinearity, heteroscedasticity and autocorrelation - estimation of LPM, Logit and Probit models - comparing two regressions - Chow test - estimation of distributed lag models – panel data random and fixed effects models - Indirect least squares
2SLS, SURE, 3SLS, estimation of simultaneous equation models

Suggested Readings

Greene WH. 2002. *Econometric Analysis*. Pearson Edu.

Johnston J & Dinardo J. 2000. *Econometric Methods*. McGraw-Hill.

Kelejan HH & Oates WE. 2001. *Introduction to Econometrics Principles and Applications*. Harper & Row.

Maddala GS. 2002. *Econometrics.* McGraw Hill.

4.AG ECON 604 ADVANCED PRODUCTION ECONOMICS 2+1

Objective

To expose the students to the concept, significance and uses of advance production economics.

Theory

UNIT I

Agricultural Production process – Relationship between farm planning and production economics-scope of agricultural production and planningmethods/ procedures in agro-economic research and planning.

UNIT II

Production functions, components, assumptions, properties and their economic interpretation - Concepts of homogeneity, homotheticity, APP, MPP, elasticities of substitution and their economic relevance – Production relations –optimality-Commonly used functional forms, nature, properties, limitations, estimation and interpretation -linear, Spillman -Cobb Douglas, quadratic, multiplicative (power)

functional forms - Translog, and transcendental functional forms -CES, production functional forms-Conceptual and empirical issues in specification, estimation and application of production functions- Analytical approaches to economic optimum - Economic optimum – determination of economic optimum with constant and varying input and output prices- Economic optimum with production function analysis - input use behaviour.

UNIT III

Decision making with multiple inputs and outputs – MRT and product relationship-cost of production and adjustment in output prices-single input and multiple product decisions- Multi input, and multi product production decisions - Decision making with no risk -Cost of wrong decisions - Cost curves – Principles and importance of duality theory - Correspondence of production, cost, and profit functions - Principles and derivation of demand and supply functions .

UNIT IV

Technology, input use and factor shares -effect of technology on input usedecomposition analysis-factor shares-estimation methods- Economic efficiency in agricultural production – technical, allocative and economic efficiency – measurement - Yield gaps analysis – concepts and measurement - Risk and uncertainty in agriculture – incorporation of risk and uncertainty in decision making – risk and uncertainty and input use level-risk programming.

UNIT V

Simulation and programming techniques in agricultural production-Multiple Course Objective Programming – Goal programming and Compromise programming – applications.

Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations-Optimal product and input choice under multi input and output system-Estimation of factor shares from empirical functions estimated-Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology- Estimation of efficiency measures – Stochastic, probabilistic and deterministic frontier production functions-Risk programming – MOTAD-Quadratic programming-Simulation models for agricultural production decisions-Goal programming – Weighted, lexicographic and fuzzy goal programming- Compromise programming.

Suggested Readings

Chambers RG. 1988. *Applied Production Analysis*. Cambridge Univ. Press.

Gardner BL & Rausser GC. 2001. *Handbook of Agricultural Economics*. Vol. IA *Agricultural Production.* Elsevier.

Palanisami KP, Paramasivam & Ranganathan CR. 2002. *Agricultural Production Economics: Analytical Methods and Applications*. Associated Publishing Co.

5.AG ECON 605 QUANTITATIVE DEVELOPMENT POLICY ANALYSIS 1+1

Objective

• The course trains the Scholars in the art of informed decision making and helps them to appreciate the value of the analytical basis in policy decisions. • They are given hands on training on the estimation and use of various criteria such as elasticities in making QDPA more meaningful

• The scholars make extensive reviews to get acquainted with the analytical relevance and in drawing inferences.

Theory

UNIT I

Policy framework – goals, value, beliefs and welfare maximization. Market – Policy and State – State vs. Market – Failure of Policy – Failure of Markets -Rationale for Government Intervention. Role of Quantitative Policy Analysis.58

UNIT II

Demand analysis for policymaking – Alternative approaches to demand analysis – Policy implications. Supply response – Alternative approaches to measurement of supply response – Nerlovian models of supply response – Policy implications.

UNIT III

Household behaviour and policy analysis – Household models.

UNIT IV

Partial equilibrium analysis – Concept of reference prices – Price distortions – indicators and impact. Transaction costs – Implications for efficiency and productivity – Institutional solutions - Multi market approach to policy analysis.

UNIT V

Social Accounting Matrices and multipliers -– Computable General Equilibrium models to assess economy wide impact of policy changes.

Practical

Review of criteria for policy evaluation – Estimation of price elasticities – Review of estimation of complete demand systems – Estimation of Nerlovian supply Response model – Review of Household models – Specification and estimation of household models – Partial equilibrium analysis – Input–output table – Social Accounting Matrix – Construction of a SAM – computation of Multipliers – Multi Market Analysis – Review of Computable General Equilibrium Models.

Suggested Readings

Chenery H & Srinivasan TN. (Eds.). 1988. *Hand book of Development Economics*. North-Holland.

Eicher KC & Staatz JM. 1998. *International Agricultural Development*. Johns Hopkins Univ. Press.

Fischer G, Miller J & Sidney MS. (Eds.). 2007. *Handbook of Public Policy Analysis: Theory, Politics and Methods*. CRC Press.

Frank E. 1992. *Agricultural Polices in Developing Countries*. Cambridge Univ. Press.

Ghatak S & Ingersent K. 1984. *Agriculture and Economic Development*. Select Book Service Syndicate.

Kindleberger PC. 1977. Economic Development. McGraw Hill.

Meier MG & Stigilitz JE. 2001. *Frontiers of Development Economics- the Future Perspective*. Oxford Univ. Press.

Sadoulet E & de Janvry A. 1995. *Quantitative Development Policy Analysis*. (London: John Hopkins Univ. Press.

Shoven Neck R, Christian R & Mooslechner P. (Eds.). 2008. *QuantitativeEconomic Policy Essays in Honour of Andrew Hughes Hallett.*

6.AG ECON 606 ADVANCED AGRICULTURAL MARKETING AND PRICE ANALYSIS 2+1

Objective

The main Course Objective of this course is to critically analyze the important marketing concepts, models, properties of agricultural commodity prices and

forecasting, data collection and analysis using current software etc., in order to make them policy decisions in the field of agricultural marketing.

Theory

UNIT I

Importance of market analysis in the agricultural system - types of marketingadvantages and disadvantages - quantitative estimation - the distinguishing 59

characteristics and role of agricultural prices - data sources for agricultural products and prices - softwares used in market analysis.

UNIT II

Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency - public - private partnership – institutional arrangements. Successful case studies.

UNIT III

Multi market estimation, supply response models. Market integration and price transmission - supply / value chain management. GAP analysis. Current trends in information in the changing agrifood system.

UNIT IV

Agricultural commodity marketing - spot and futures- marketing of derivatives- speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity markets- Regulatory mechanism of futures trading.

UNIT V

Lag operators and difference equations; stationary and stochastic processes; UNIT roots and cointegration; conditional heteroscedasticity: ARCH and GARCH models - forecast evaluation; methods of forecasting. price indices and econometric estimation and simulation.

Practical

Estimation of demand/ supply forecasting, supply chain / value chain analysis for different commodities - Commodity models- multi market estimation- time series analysis - market integration studies- price discovery price volatility estimation - commodity price forecasting using

econometric softwares.

Suggested Readings

Ferris JN. 1998. *Agricultural Prices and Commodity Market Analysis*. McGraw-Hill.

Goodwin JW. 1994. *Agricultural Price Analysis and Forecasting*. Wiley.

Hallam D. 1990. *Econometric Modeling of Agricultural Commodity Markets*. New Routledge.

Martimort D. (Ed.). 1996. *Agricultural Markets: Mechanisms, Failures, and Regulations*. Elsevier.

Schrimper RA. 2001. *Economics of Agricultural Markets*. Pearson.

Timmer CP. 1986. *Getting Prices Right.* Cornell University Press.

Tomek WG & Robinson KL. 2003. *Agricultural Product Prices*. 4th Ed. Cornell University Press.

7. AG ECON 607 COMMODITY FUTURES TRADING 2+0

Objective

This course is aimed at providing the basic understanding and the mechanics and value of futures markets for speculators and hedgers which in turn will serve asprice risk management activities of agribusiness firms.

Theory

UNIT I

History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Speculatory mechanism in commodity futures.

UNIT II

Transaction and settlement – delivery mechanism - role of different agents -trading strategies - potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.

UNIT III

Risk in commodity trading, importance and need for risk management measures - managing market price risk: hedging, speculation, arbitrage, swaps - pricing and their features.

UNIT IV

Important global and Indian commodity exchanges - contracts traded – special features -Regulation of Indian commodity exchanges - FMC and its role.

UNIT V

Fundamental Vs Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend – Market indicators – back testing. Introduction to technical analysis software – analyzing trading pattern of different commodity groups.

Suggested Readings

Kaufman PJ**.** *1986. The Concise Handbook of Futures Markets*. John Wiley & Sons.

Leuthold RM, Junkus JC & Cordier JE. 1989. *The Theory and Practice of Futures Markets***.** Lexington Books.

Lofton T. 1993. *Getting Started in Futures*. 3rd Ed. John Wiley & Sons.

Purcell WD. 1991. *Agricultural Futures and Options: Principles and Strategies***.** Macmillan Publ.

Wasendorf RR & McCafferty. 1993. *All about Commodities from the Inside Out.*McGraw-Hill.

8.AG ECON 608 NATURAL RESOURCE MANAGEMENT 1+1

Objectives

This is an applied economics course that focuses on the economic analysis of natural resources, and seeks to identify and solve natural resource management problems via mathematical approach using dynamic optimization techniques. During the course, we will encounter bio-economic models of natural resources including the classic and more recent forestry and fisheries models, models of land and water use and extraction of non-renewable resources (such as from a mineral deposit). We will focus on intuition and understanding of the economic analysis rather than complicated mathematical models in this class. That said, natural resource problems are inherently dynamic, so some mathematical modeling of biophysical and economic processes will be required. Using computers as an aid to understanding the models will be an important part of the class. The primary tool will be Microsoft Excel, which is the easiest introduction to computational optimization and graphical representation of the results.

Theory

UNIT I

Natural resources - definition - characteristics and classification. Stock dynamics of renewable and non-renewable resources. Equation of motion for renewable and non-renewable resources. Fundamental equation of renewable resources.

UNIT II

Growth curves of fishery and forest resources. The role of time preference in natural resource use. Simple two-period model of optimal use of renewable and non-renewable resources. Advanced models of optimal resource use – Static Vs. dynamic efficiency in natural resource use Applications of dynamic programming and optimal control.

UNIT III

Economics of groundwater use - optimal extraction of groundwater. Analytical and numerical solutions for optimal inter-temporal allocation of natural resources. Optimal harvesting of single rotation and multiple rotation forests. Optimal management of fishery.

UNIT IV

Property rights in natural resources and their implication for conservation and management of natural resources. Management of common property natural resources – Institutional arrangements for conservation and management of common pool fishery, groundwater and forestry resource.

UNIT V

Resource scarcity – Natural resource degradation – Poverty and resource degradation – Natural resource accounting - Pricing and valuation of natural resources – Natural resources policy.

Practical

Derivation of the fundamental equation of renewable resources-Estimation of growth curves and stock dynamics for fishery and forestry resources. Simple two period problem of optimal resource use – Numerical solution for simple twoperiod model of dynamic efficiency in natural resource extraction. Multi-period dynamic efficiency – Using Excel Solver in solving dynamic natural resource harvesting problems. Using analytical solution procedures for solving natural resource management problems – Optimal control.

Suggested Readings

Baland J-M & Platteau JP. 1996. *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* Clarendon Press and FAO.

Carlson GA, Miranowski J & Zilberman D. 1998. *Agricultural and Environmental Resource Economics*. Oxford Univ. Press.

Chiang AC. 1992. *Elements of Dynamic Optimization*. Waveland Press.

Clark CW. 1976. *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*. John Wiley and Sons.

Conrad JM & Clark CW. 1997. *Natural Resource Economics: Notes and Problems*. Cambridge Univ. Press.

Conrad JM. 1999. *Resource Economics*. Cambridge University Press.

Fisher AC. 1981. *Resource and Environmental Economics*. Cambridge Univ.Press.

Prato T. 1998. *Natural Resource and Environmental Economics*. Iowa State Univ. Press.

Sterner T. 2003. Policy Instruments for Environmental and Natural Resource Management. Resources for the Future, Washington DC.

9. AG ECON 609 ENVIRONMENTAL ECONOMICS 2+1

Objective

The main objective of this course is to provide an advanced treatment of the economic theory of environmental management and policy, externalities and market and non-market approaches to environmental improvement. Topics in economic growth and environmental problems, poverty and environmental degradation, conservation and sustainable economic growth, intergenerational and global environmental problems, policy issues in environmental regulation and management will be covered at a sufficient depth so as to equip the students with the recent developments in the field.

Theory

UNIT I

Environmental pollution as a consequence of market failure - Causes and consequences of market failure - Externalities - Public goods and externalities - Economics of pollution – Private vs. Social cost of environmental pollution – Property rights, environment and development – Theory of environmental policy.

UNIT II

Environmental cost benefit analysis - Environmental impact assessment techniques - Non-market valuation of environmental resources (WTP / WTA) - Environment, market and social welfare.

UNIT III

Economic growth and environmental cost - Growth oriented economic policies and their environmental impacts - Population and environmental quality – poverty and environmental degradation – Sustainable development – Indicators of sustainable development – Issues in sustainable development.

UNIT IV

Environment, ecology and environmental accounting - Environmental pollution with respect to water and air - Land and forest resources related environmental pollution - Coastal externalities - Urbanization and environment – Basic approaches to environmental policy (Tax, subsidy, pollution permits etc.) Green taxes - Political economy of environmental regulation and management.

UNIT V

Transboundary environmental problems - Economics of global warming, climate change and emission trading - Environment, international trade and development.

Practical

Contemporary global environmental global environmental issues, movement, policies, programmes, laws and other regulatory mechanisms - Criteria forevaluating the environment related projects and review of Environmental Impact Assessment (EIA) techniques - Recreation demand models of environmental
valuation - Contingent valuation techniques - Environmental Resource Accounting Techniques - Discussion on the techniques dealing with air pollution and review of case studies on air pollution and its impacts - forest environment and wild life conservation - Green GDP and Green house insurance - Practical considerations and comparison of instruments of environmental policy - Non-point source pollution control methodologies - Environment in macroeconomic modeling -
Meta-analysis, economic valuation and environmental economics - Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problems related to environment - Input output analysis, technology and the environment - Computable general equilibrium models for environmental economics and policy
analysis.

Suggested Readings

Carlson GA, Miranowski J & Zilberman D. 1998. *Agricultural and Environmental Resource Economics*. Oxford Univ. Press. 63

Hanley N, Shogren J & White B. 2007. *Environmental Economics in Theory and Practice*. Palgrave, London.

Kolstad C. 1999. *Environmental Economics*. Oxford Univ. Press.

Prato T. 1998. *Natural Resource and Environmental Economics*. Iowa State Univ. Press.

Sterner T. 2003. *Policy Instruments for Environmental and Natural Resource Management. Resources for the Future*. The World Bank and SIDA.

List of Journals

- Agricultural Economics Research Review
- Agricultural Finance Review
- Agricultural Marketing
- Agriculture and Agro-industries Journal
- Agriculture Statistics at a Glance
- APEDA Trade yearbook
- Asian Economic and Social Review (Old Series)
- Bulletin of Agricultural Prices
- Economic and Political Weekly
- Economic Survey of Asia and Far East
- FAO Commodity Review and Outlook
- FAO Production Year book
- FAO Trade year book
- Indian Cooperative Review
- Indian Economic Journal
- Indian Journal of Agricultural Economics
- Indian Journal of Agricultural Marketing
- Indian Journal of Economics
- International Food Policy Research Institute Research Report
- Journal of Agricultural Development and Policy
- Journal of Agricultural Economics
- Journal of Agricultural Economics and Development
- Journal of Farm Economics
- Land Economics
- Productivity
- Reserve Bank of India Bulletin
- Rural Economics and Management
- World Agricultural Economics and Rural Sociology Abstracts
- World Agricultural Production and Trade: Statistical Report
- Yojana
- Agricultural Situation in India

e- Resources

- www.pearsoned.com (Pearson Education Publication)
- www.mcgraw-hill.com (McGraw-Hill Publishing Company)
- www.oup.com (Oxford University Press)
- www.emeraldinsight.com (Emerald Group Publishing)
- www.sagepub.com (*S*age publications)
- www.isaeindia.org (Indian Society of Agricultural Economics)
- www.macmillanindia.com (Macmillan Publishing)

• www.icar.org.in (Indian Council of Agricultural Research)
• www.khoj.com (Directory for Agricultural Economics)65
• www.ncap.res.in (National Centre for Agricultural Economics and Policy Research)
• www.ncdex.com (National Commodity & Derivatives Exchange Limited)
• www.phdcci.in (PHD Chamber of Commerce and Industry)
• www.ficci.com (Federation of Indian Chambers of Commerce and Industry)
• www.assocham.org (Associated Chambers of Commerce and Industry of India)
• www.apeda.com (Agricultural and Processed Food Products Export Development Authority)
• www.mpeda.com (Marine Products Export Development Authority)

IX AGRICULTURAL EXTENSION

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	Credits
EXT 501*	DEVELOPMENT PERSPECTIVES OF EXTENSION EDUCATION	1+1
EXT 502*	DEVELOPMENT COMMUNICATION AND INFORMATION MANAGEMENT	2+1
EXT 503*	DIFFUSION AND ADOPTION OF INNOVATIONS	2+1
EXT 504*	RESEARCH METHODS IN BEHAVIORAL SCIENCES	2+1
EXT 505*	E-EXTENSION	2+1
EXT 506*	ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT IN EXTENSION	2+1
EXT 507*	HUMAN RESOURCE DEVELOPMENT	2+1
EXT 508	VISUAL COMMUNICATION	2+1
EXT 509	PARTICIPATORY METHODS FOR TECHNOLOGY DEVELOPMENT AND TRANSFER	1+1
EXT 510	GENDER SENSITIZATION FOR DEVELOPMENT	2+1
EXT 511	PERSPECTIVES OF DISTANCE EDUCATION	2+0
EXT 512	MARKET-LED EXTENSION	1+1
EXT 591	MASTER'S SEMINAR	0+1
EXT 599	MASTER'S RESEARCH	20
EXT 601**	ADVANCES IN AGRICULTURAL EXTENSION	2+1
EXT 602**	ADVANCED DESIGN AND TECHNIQUES IN SOCIAL SCIENCE RESEARCH	2+1
EXT 603**	ADVANCES IN TRAINING TECHNOLOGY	2+1
EXT 604**	ORGANIZATIONAL DEVELOPMENT	2+1
EXT 605**	ADVANCED INSTRUCTIONAL TECHNOLOGY	2+1
EXT 606	THEORY CONSTRUCTION IN SOCIAL SCIENCES	2+0
EXT 607	ADVANCED MANAGEMENT TECHNIQUES	2+1
EXT 608	MEDIA MANAGEMENT	2+1
EXT 609	TRANSFER OF TECHNOLOGY IN AGRICULTURE	2+1
EXT 691	DOCTORAL SEMINAR I	0+1
EXT 692	DOCTORAL SEMINAR II	0+1
EXT 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

1. EXT 501 DEVELOPMENT PERSPECTIVES OF EXTENSION EDUCATION 1+1

Objective

The course is intended to orient the students with the concept of extensioneducation and its importance in Agriculture development and also to expose the students with various rural development programmes aimed at poverty alleviation and to increase employment opportunities and their analysis. Besides, the students will be learning about the new innovations being brought into the Agricultural Extension in India.

Theory

UNIT I

Introduction to Extension Education: Meaning, objectives, concepts, principles and philosophy, critical analysis of definitions; Extension Education as a Profession; Adult Education and Distance Education.

UNIT II

Pioneering Extension efforts and their implications in Indian Agricultural Extension – Analysis of Extension systems of ICAR and SAU – State Departments Extension system and NGOs – Role of Extension in Agricultural University.

UNIT III

Agriculture in Indian rural setting; Sustainable agriculture: Concepts, Challenges, Green revolution, LEISA, Challenges in water front, IPM; Conservation of natural resrources; Climate change; Development Planning: Constitutional provisions, Five-year plans; Different approaches - Socialist, Capitalist, Gandhian, Nehruvian, PURA (of Dr. Abdul Kalam) etc.; Concepts: Empowerment, Economic Reforms: Liberalisation, Privatisation, Globalisation; Income growth and distributive justice: Growth parameters, Coefficients of Inequality, Gender concerns, Inclusive growth; Poverty Alleviation Programmes – SGSY, SGRY, PMGSY, DPAP, DDP, CAPART; State-specific programmes - Kudumbasree; Employment Generation Programmes – NREGP; Women Development Programmes – ICDS, MSY, RMK; Problems in Rural Development.

UNIT IV

Current Approaches in Extension: Bottom up planning; Decentralised Development Planning, Farming System Approach, Watershed-based planning; Farming-situation-based Extension, Market–led Extension, e-Extension, Farm Field School, ATIC, Kisan Call Centres, NAIP.

Practical

Visit to Gram Panchayat and Panchayat-level agricultural office to study on-going Rural Development and agriculture programmes; Visit to KVK, NGO and Extension centers of State Agricultural University and State Departments, Report preparation and presentations.

Suggested Readings

Chandrakandan KM, Senthil Kumar & Swatilaxmi. PS**.** 2005. *Extension Education: What? And What Not ?* RBSA Publ.

Gallagher K. 1999. *Farmers Field School (FFS) – A Group Extension Process based on Non-Formal Education Methods*. Global EPM Facility, FAO.

Ganesan R, Iqbal IM and Anandaraja N. 2003. *Reaching the Unreached: Basics of Extension Education*. Associated Publishing Co.

Jalihal KA & Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension*. Concept Publ.

Khan PM. 2002. *Textbook of Extension Education*. Himalaya Publ.

Ray GL. 2006. *Extension Communication and Management*. Kalyani Publ.

Van Den Ban AW & Hawkins HS. 1998. *Agricultural Extension* .2nd Ed. CBS.

Viswanathan M. 1994. *Women in Agriculture and Rural Development*. Printwell Pub.
Melkote, Srinivas R. 1991. Communication for development in Third World.
New Delhi. Sage.
Pretty, Jules N. (1996). Regenerating Agriculture. Policies and practice for sustainability and self-reliance. Vikas Publishing House, New Delhi.
Also available at books.google.com.
Melkote, Srinivas R. and H. Leslie Steeves. 2001. Communication for development in Third World. Theory and Practice for empowerment.
Also available at books.google.com
Swanson. Agricultural Extension: A Reference Manual.
Rolling, Neils. 1988 Extension Science. Information systems in agricultural development. Cambridge University Press, Cambridge.
Roling, N.G., Wagemakers, M.A.E. Facilitating sustainable agriculture: Participatory learning and adaptive management in times of environmental uncertainty. Cambridge University Press. Cambridge.
Datt, Ruddar and KPM Sundharam. 2008. Indian Economy. S. Chand, New Delhi.
Government of India. Economic survey (recent issue). Planning Commission.
New Delhi.
Government of India. Agricultural Statistics (recent issue). Ministry of Agriculture and Cooperation. New Delhi.
Government of Kerala. Economic review (recent issue). State Planning Board.
Thiruvananthapuram.
Government of Kerala. 2001. Data Book on Agriculture. State Planning Board.
Thiruvananthapuram.

2. EXT 502 DEVELOPMENT COMMUNICATION AND INFORMATION MANAGEMENT 2+1

Objective

In this course, students will learn about the concept, meaning and process ofcommunication and various methods and modern media of communication. Besides, the students will also learn the information management and journalistic writing of various information materials and also study their readability.

Theory

UNIT I

Introduction to development and communication. Evolution of the theory and practice of development. Economic models of development; Sociology of development; Criticisms on paradigms of development; Alternative perspectives on development. Participatory communication Information Management: Meaning, Scope and Relevance. Communication process – concept, elements and their characteristics – Models and theories of communication – Communication skills– fidelity of communication, entropy; communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks and Development communication – Barriers in communication, Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message. Channels of communication - Classification of channels and their characteristics; Localite cosmopolite, mass media and interpersonal channels.

UNIT II

Methods of communication – Meaning and functions, classification. Forms of communication – Oral and written communication, Non-verbal communication, interpersonal communication, organizational communication. Levels of

communication; Key communicators – Meaning, characteristics and their role in development.

UNIT III

Media in communication – Role of mass media in dissemination of farm technology, Effect of media mix for Rural People. Modern communication media – Electronic video, Tele-Text, Tele conference, Computer Assisted Instruction, Computer technology and its implications in development.

UNIT IV

Agricultural Journalism as a means of mass communication, Its form and role in rural development, Basics of writing – News stories, feature articles, magazine articles, farm bulletins and folders. Techniques of collection of materials for news stories and feature articles; Art of clear writing, Readability and comprehension testing procedures; photo journalism, communicating with pictures, Radio and TV Journalism, Techniques of writing scripts for Radio and TV.

Suggested Readings

Dahama OP & Bhatnagar OP. 2005. *Education and Communication for Development.* Oxford & IBH.

Grover I, Kaushik S, Yadav L & Varma SK. 2002. *Communication andInstructional Technology*. Agrotech Publ. Academy.

Jana BL & Mitra KP. 2005. *Farm Journalism*. Agrotech Publ. Academy.

Ray GL. 2006. *Extension Communication and Management*. Kalyani Publ.

Rayudu CS.2002. *Communication*. Himalaya Publ. House.

Reddy AA. 1987. *Extension Education*. Sree Lakshmi Press, Bapatla.

Sandhu AS. 2004. *Textbook on Agricultural Communication Process andMethods*. Oxford & IBH.

Melkote, Srinivas R. and H. Leslie Steeves. 2001. Communication for development in Third World. Theory and Practice for empowerment.

(Also available at books.google.com)

Roling, Neils. 1988. Extension Science. Information Systems in Agricultural development. Cambridge. New York.

Ray, G.L. Extension communication and management. Maya Prokash. Calcutta.

3.EXT 503 DIFFUSION AND ADOPTION OF INNOVATIONS 2+1

Objective

The students will learn how the agricultural innovations spread among the farmers in the society by getting into the insights of diffusion concept and adoption process, stages of adoption and innovation decision process, adopter categories and their characteristics, opinion leaders and their characteristics, attributes of innovations, and factors influencing adoption. In addition, the students would be learning various concepts related to diffusion and adoption of innovations.

Theory

UNIT I

Communication for development: Critique of dominant paradigms of development, Participatory communication; Diffusion – concept and meaning, elements; traditions of research in diffusion; the generation of innovations; innovation-development process; tracing the innovation-development process, converting research into practice.

UNIT II

The adoption process: concept and stages, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process.

UNIT III

Adopter categories – Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories; Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption.

UNIT IV

Diffusion effect and concept of over adoption, opinion leadership- measurement and characteristics of opinion leaders, monomorphic and polymorphic opinion leadership, multi-step flow of innovation; concepts of homophily and heterophily and their influence on flow of innovations; Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions; Consequences of Innovation-Decisions – Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences; Decision making – meaning,theories, process, steps, factors influencing decision making.

Practical

Case studies in individual and community adoption process, content analysis of adoption studies, Identification of adopter categories on a selected technology,study of attributes of current farm technologies, Identification of opinion leaders,Sources of information at different stages of adoption on a selected technology,study of factors increasing or retarding the rate of adoption, presentation of reports on adoption and diffusion of innovations.

Suggested Readings

Dasgupta. 1989. *Diffusion Agricultural Innovations in Village India*. Wiley Eastern.

Jalihal KA & Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension.* Concept Publ. Co.

Ray GL. 2005. *Extension Communication and Management*. Kalyani Publ.

Reddy AA. 1987. *Extension Education.* Sree Lakshmi Press, Bapatla.

Rogers EM. 2003. Diffusion of Innovations. 5th Ed. The Free Press, New York.

Melkote, Srinivas R. and H. Leslie Steeves. 2001. Communication for development in Third World. Theory and Practice for empowerment.

(Also available at books.google.com)

4.EXT 504 RESEARCH METHODS IN BEHAVIOURAL SCIENCE 2+1

Objective

This course is designed with a view to provide knowledge and skills in methods of behavioural sciences research and students will learn the Statistical Package for Social Sciences (SPSS) for choosing appropriate statistics for data analysis.

Theory

UNIT I

Research: Meaning, importance, characteristics. Behavioural sciences research – Meaning, concept and problems in behavioural sciences research. Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study. Review of literature – Need, Search Procedure, Sources of literature, Planning the review work. Research problem – Selection and

Formulation of research problem and guiding principles in the choice of research problem, Factors and criteria in selection of research problem, statement of research problem and development of theoretical orientation of the research problem.

UNIT II

Objectives: Meaning, types and criteria for judging the objectives. Concept and Construct: Meaning, role of concepts in research and Conceptual frame

workdevelopment in research. Variable – Meaning, types and their role in research.Definition – Meaning, characteristics of workable definitions, types and their role in research. Hypothesis – Meaning, importance and functions of hypothesis in research, Types of hypothesis, linkages, sources, problems in formulation and criteria for judging a workable hypothesis. Measurement – Meaning, postulates
and levels of measurement, Appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research. Validity – Meaning, Types and methods of testing. Reliability – Meaning, types and methods of testing. Sampling – Universe, Sample and Sampling- Meaning, basis for sampling, advantages and limitations, size and factors affecting the size of the sample and sampling errors – Methods of elimination and minimizing, Sampling – Types of sampling and sampling procedures.

UNIT III

Research Designs – Meaning, purpose and criteria for research design, Principle of MAXMINCON, Types, Ex-post facto and experimental, Data Collection methods - Interview – Meaning, purpose, types, techniques of interviewing and advantages and limitations. Enquiry forms and Schedules – Meaning, types of questions used, steps in construction and advantages and limitations in its use. Questionnaires – Meaning, difference between schedule and questionnaire, types of questions to be used, pre–testing of the questionnaires or schedules. Check lists – Meaning, steps in construction, advantages and limitations in its use. Rating scales – Meaning, types, limits in construction, advantages and limitations in its use. Observation – Meaning, types, tips in observation, advantages and limitations in its use. Case studies – Meaning, types, steps in conducting, advantages and limitations in its use. Social survey – Meaning, objectives, types and steps in conducting; Advantages and limitations. Qualitative research: Nature and relevance of qualitative inquiry, Qualitative designs, data collection and interpretation.

UNIT IV

Data processing – Meaning, coding, preparation of master code sheet, analysis and tabulation of data, Statistical Package for Social Sciences (SPSS) choosing appropriate statistics for data analysis based on the level of measurement of variables. Report writing – Meaning, guidelines to be followed in scientific report writing, References in reporting.

Practical

Selection and formulation of research problem - Formulation of objectives and hypothesis-Selection of variables based on objectives-Developing the conceptual framework of research. Operationally defining the selected variables-Development of data collection devices.-Testing the validity and reliability of the data collection instruments and pre-testing - Techniques of interviewing and collection of data using the data collection instruments-Data processing, hands on experiences on SPSS, coding, tabulation and analysis. Formulation of secondary tables based on objectives of research.Writing report, Writing of thesis and research articles-Presentation of reports.

Suggested Readings

Chandrakandan K, Venkatapirabu J, Sekar V & Anand Kumar V. 2000. *Tests and Measurements in Social Research*. APH Publ.

Kerlinger FN. 1973. *Foundations of Behavioural Research*. Holt Rhinehart.

Kothari CR.1984. *Research Methodology, Methods and Techniques*. Chaitanya Publ. House.

Krishnaswami OR & Ranganatham M. 2005. *Methodology of Research in Social Sciences*. Himalaya Publ. House.

Mulay S & Sabaratnam VE.1983. *Research Methods in Extension Education*. Manasavan.
Ranjit Kumar. 1999. *Research Methodology - A Step by Step Guide for Beginners*. Sage Publ.
Ray GL & Sagar Mondal. 1999. *Research methods in Social Sciences and Extension Education*. Naya Prokash.
Wilkinson TS & Bhandarkar PC.1993. *Methodology and Techniques of Social Research*. Himalaya Publ.Home.
Edwards, Allen L. 1969. Techniques of Attitude Scale Construction. Vakils, Feffer and Simons Pvt. Ltd. Bombay.
Patton, Michael Quinn. Qualitative research and evaluation methods. Amazon.com.
Siegel, Sidney and Castellan, Jr. NJ. 1988. Non-parametric Statistics for Behavioural Sciences. McGraw Hill. Tokyo.

5. EXT 505 E-EXTENSION 2+1

Objective

Students will gain knowledge and skills in understanding the concepts of Information and communication technologies and how these ICT tools can be used for Agricultural Extension. Besides, s/he studies various ICT projects which are successful in delivering the services to the clientele fulfilling the objective of Transfer of Technology.

Theory

UNIT I

ICTs - Concept, definition, tools and application in extension education. Reorganizing the extension efforts using ICTs, advantages, limitations and opportunities.

UNIT II

ICTs projects, case studies in India and developing world. Different approaches (models) to ICTs. Use of ICT in the field of extension- Expert systems on selected crops and enterprises; Self learning CDs on package of practices, diseases and pest management, Agricultural web sites and portals related crop production and marketing etc.

UNIT III

Community Radio, Web-, Tele-, and Video-conferencing. Computer-Aided Extension. Knowledge management, Information kiosks, Multimedia. Online, Offline Extension. Tools-Mobile technologies, e-learning concepts; Community radio forums and Knowledge centres.

UNIT IV

ICT Extension approaches-pre-requisites, information and science needs of farming community. Need integration. Human resource information.Intermediaries. Basic e-extension training issues. ICT enabled extension pluralism. Emerging issues in ICT.

Practical

Agricultural content analysis of ICT Projects. Handling of ICT tools. Designing extension content. Online extension service. Project work on ICT enabled extension. Creation of extension blogs. Visit to ICT extension projects.

Suggested Readings

Batnakar S & Schware R. 2000. *Information and Communication Technology in Development- Cases from India*. Sage Publ.
Meera SN. 2008. *ICTs in Agricultural Extension: Tactical to Practical*. Ganga- Kaveri Publ. House. JangamWadiMath, Varanasi.
Willem Zip. 1994. *Improving the Transfer and Use of Agricultural Information – A Guide to Information Technology*. The World Bank, Washington.

6.EXT 506 ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT IN EXTENSION 2+1

Objective

The first part of the course is intended to provide overall picture of planning and development of enterprises for extending sustainable livelihoods for rural people. The second part of the course is structured to help the students to gain knowledge and skills in different concepts and techniques of management in extension organizations.

Theory

UNIT I

Entrepreneurship, Leadership and Allied concepts: Entrepreneurship – Concept, characteristics, Approaches, Theories, Need for enterprises development. Agri – entrepreneurship – Concept, characteristics, Nature and importance for sustainable Livelihoods. Traits of entrepreneurs – Risk taking, Leadership, Decision making, Planning, Organising, Coordinating and Marketing, Types of Entrepreneurs. Stages of establishing enterprise – Identification of sound enterprise, steps to be considered in setting up an enterprise, feasibility report, product selection, risk and market analysis, legal requirements. Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects.

UNIT II

Micro enterprises – Profitable Agri enterprises in India – Agro Processing, KVIC industries. Micro financing – meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises – Concept, planning for marketing, target marketing, Competition, market survey and strategies, Product sales and promotion. Gender issues in entrepreneurship development – Understanding gender and subordination of women, Gender as a development tool, Policy approaches for women entrepreneurship development. Success and Failure stories for enterprises – Issues relating to success and failure of enterprises – Personal, Production, Finance, Social, Marketing.

UNIT III

Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Qualities and skills of a manager. Extension Management – Meaning, Concept, Importance, Principles of management, Classification of Functions of Management. Planning – Concept, Nature, Importance, Types, Making planning effective. Change Management – factors, process and procedures. Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions. Organizing – Meaning of Organization, Concept, Principles, Organizational Structure, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations.

UNIT IV

Coordination – Concept, Need, Types, Techniques of Coordination. Interpersonal relations in the organization. Staffing – Need and importance, Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development – Performance appraisal – Meaning, Concept, Methods. Direction – Concept, Principles, Requirements of effective direction, Giving orders, Techniques of direction. Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles. Organizational Communication – Concept, Process, Types, Net Works, Barriers to Communication. Managing work motivation – Concept, Motivation and Performance, Approaches to motivation. Supervision – Meaning, Responsibilities, Qualities and

functions of supervision, Essentials of effective supervision. Managerial Control – Nature, Process, Types, Techniques of Control, Budgeting, Observation, PERT and CPM, MIS.

Practical

Field visit to Successful enterprises-Study of Characteristics of Successful entrepreneurs Development of Project Proposal -Case Studies of Success / Failure enterprises-Exercise on Market Survey-Field visit to Financial institutions- Simulated exercise to understand management process-Field visit to extension organizations to understand the functions of management -Group exercise on development of short term and long term plan-Simulated exercise on techniques of decision making-Designing organizational structure -Group activity on leadership development skills.

Suggested Readings

Gupta CB. 2001. *Management Theory and Practice*. Sultan Chand & Sons.
Indu Grover. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
Khanka SS. 1999. *Entrepreneurial Development*. S. Chand & Co.
Singh D. 1995. *Effective Managerial Leadership*. Deep & Deep Publ.
Tripathi PC & Reddy PN. 1991. *Principles of Management*. Tata McGraw Hill.
Vasanta Desai. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House.
Grover, Indu. 2008. Handbook on Empowerment and Entrepreneurship. Agrotech Publishing Co., Udaipur.

7.EXT 507 HUMAN RESOURCE DEVELOPMENT (HRD) 2+1

Objective

To orient the students about key concepts importance, scope & conceptual frame work, growth & development of Human Resource Development, Subsystems of Human Resource Development for extension organization and process of HRD.

Theory

UNIT I

Human Resource Development – Definition, Meaning, Importance, Scope and Need for HRD; Conceptual frame work, inter disciplinary approach, function systems and case studies in HRD; Millennium Development Goals; Human Development Index: Gender-related Development Index, Human Poverty Index; HRD Interventions – Different Experiences; Selection, Development & Growth- Selection, Recruitment, Induction Staff Training and Development, Career planning; Social and Organizational Culture: Indian environment perspective on cultural process and social structure, society in transition; Organizational and Managerial values and ethics, organizational commitment ; Motivation productivity - job description – analysis and evaluation; Performance Appraisal.

UNIT II

Human Resource management: Collective bargaining, Negotiation skills; Human Resource Accounting (HRA): What is HRA? Why HRA? Information Management for HRA and Measurement in HRA; Intra personal processes: Collective behaviour, learning, and perception ; Stress and coping mechanisms;Inter-Personal Process, Helping Process – communication and Feedback and interpersonal styles; Group & Inter group process: group information and group processes; Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition; HRD & Supervisors: Task Analysis; Capacity Building – Counseling and Mentoring; Role of a Professional Manager: Task of Professional

Manager – Responsibility of Professional Manager; Managerial skills and Soft Stills required for Extension workers; Decision Making: Decision Making models, Management by Objectives; Behavioural Dynamics :Leadership styles – Group dynamics.

UNIT III

Training – Meaning, determining training need and development strategies –Training types, models, methods and evaluation; Facilities for training – Trainers training – techniques for trainees participation; Research studies in training extension personnel; Main issues in HRD: HRD culture and climate – organizing for HRD – emerging trends and Prospective.

Practical

Visit to different training organizations to review on going activities & facilities; Analysis of Training methods followed by training institutions for farmers and extension workers Studies on evaluation of training programmes; Study of HRD in organization in terms of performance, organizational development, employees welfare and improving quality of work life and Human resource information, Presentation of reports.

Suggested Readings

Agochiya D. 2002. *Every Trainer's Handbook*. Sage Publ.

David Gross. 1997. *Human Resource Management - The Basics*. TR Publ.

Davis Keth & Newston W John 1989. Human Behaviour at Work. 8th Ed.McGraw-Hill.

Hersey Paul & Balanchard H Kenneth. 1992. *Management of Organizational Behaviour Utilizing Human Resource*. 5th Ed. Prentice-Hall of India.

Knoontz Harold & Weihhrich Heinz 1990. *Essentials of Management*. 5th Ed. McGraw-Hill.

Lynton RP & Pareek U. 1993. *Training for Development*. DB.Taraporewale Sons& Co.

Punna Rao P & Sudarshan Reddy M. 2001. *Human Resource Development Mechanisms for Extension Organization*. Kalyani Publ.

Rao TV. 2003. *Readings in Human Resource Development*. Oxford Publ.Co.

Silberman Mel. 1995. *Active Training*. Press Johnston Publ. Co., New Delhi.

Singh RP. 2000. *Management of Training Programmes*. Anmol Publ.

Subba Rao P. 2005. *Management & Organizational Behaviour*. Himalaya Publ.House.

Sundaram RM, Gupta V, George SS. 2006. *Case Studies in HumanResource Management*.ICFAI, Hyderabad.

Tripati & Reddy. 2004. *Principles of Management*. Tata McGraw-Hill.

Wayne MR & Robert MN. 2005. *Human Resource Management*.International Ed. Pearson Prentice Hall.

UNDP. 2009. Human Development Report 2009. Oxford University Press.

The World Bank. 2009. World Development Report. Reshaping Economic Geography. Washington, DC.

Government of India. National Human Development Report. (2001, or later). Planning Commission. New Delhi.

8.EXT 508 VISUAL COMMUNICATION 2+1

Objective

This course is intended to give a clear perspective about the importance of visuals and graphics in communication. The course starts with the delineating about the characteristics of visuals and graphics followed by its main functions, theories of visual perception and its classification and selection. Further, the course deals with the

designing of the message, graphic formats and devices and presentation of data. It makes the students to understand, prepare and present the scientific data effectively by using low cost visuals. The course also exposes the students to
various digitized video materials in multimedia and also enable to design visuals for print, TV and know-how about scanning of visuals.

Theory

UNIT I

Role of visuals & graphics in Communication. Characteristics and Functions of visuals and graphics. Theories of visual perception; Classification and selection of visuals.

UNIT II

Designing message for visuals, Graphic formats and devices. Presentation of Scientific data. Principles and production of low cost visuals.

UNIT III

Photographs- reprographic visuals. PC based visuals. Degitized video material in multimedia production. Designing visuals for print, TV and video.

UNIT IV

Pre-testing and evaluation of visuals. Scanning of visuals.

Practicals

Preparation of low-cost projected and Non-projected visuals. Designing and layout of charts, posters, flash cards etc. Power point presentations. Generating computer aided presentation graphics. Scanning and evaluation of visuals.

Suggested Readings

Bhatia A. 2005. *Visual Communication*. Rajat Publications, New Delhi.

Edgar Dale 1970. *Audio Visual methods in Teaching*. Holt, Rinehart & Winston.

James WB, Richard BL, Fried F Harcleroad. 1952. *A.V. Instructional Material &Methods*. Mc.Graw Hill.

Reddy YN. 1998. *Audio Visual Aids in Teaching, Training and Extension*. Haritha Publ. House, Hyderabad.

9.EXT 509 PARTICIPATORY METHODS FOR TECHNOLOGY DEVELOPMENT AND TRANSFER 1+1

Objective

This course is intended to orient the students with the key concepts, principles,process of different participatory approaches for technology development and transfer and also to expose the students with various participatory tools and techniques like space-related, time-related, relation-oriented methods. Besides the students will be learning the preparation of action plans participatory monitoring and evaluation.

Theory

UNIT I

Participatory extension – Introduction to concepts and approaches; Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models.

UNIT II

Participatory tools and techniques. Space-related Methods : village map (social & resource), mobility services and opportunities map and transect; Time related methods : time line, trend analysis, seasonal diagram. Daily activity schedule, dream map; Relation oriented methods : cause and effect diagram (problem tree),impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis.

UNIT III

Preparation of participatory action plans, concept and action plan preparation; Participatory technology development and dissemination; Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation.

Practical

Simulated exercises on participatory approaches; space-related methods, time-related methods and-relation oriented methods; Documentation of PTD and dissemination; Preparation of action plan; Participatory monitoring and evaluation of developmental programmes.

Suggested Readings

Adhikary. 2006. *Participatory Planning and Project Management in Extension Science*. Agrotech Publ. Academy.

Mukharjee N. 2002. *Participatory Learning and Action*. Concept Publ. Co.

Singh BK. 2008. *PRA/PLA and Participatory Training*. Adhyayan Publ. & Distr.

Somesh Kumar. 2002. *Methods for Community Participation*. Vistaar Publ.

10 EXT 510 GENDER SENSITIZATION FOR DEVELOPMENT 1+1

Objective

In this course the students will learn about an overview of the concept of genderand gender balance on development and develop skills of identifying genderroles, rights, responsibilities and relationships on development. Besides the students will also learn the attitudinal change to internalize gender equity concerns as fundamental human rights and also enhance the capability for identifying and analyzing gender issues in agriculture and allied sectors.

Theory

UNIT I

Gender development as a human right issue; Women in agriculture, Women in Home and Farm: Roles, value and significance; Gender concepts, issues and challenges in development; Gender roles, gender balance, status, need and scope; Gender analysis: Tools and techniques.

UNIT II

Gender equity in India; National policy for empowerment of women since independence; Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors – need and relevance; Gender budgeting – A tool for empowering women.

UNIT III

Women empowerment –Dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role in economic development; Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women human rights ; Action plans for gender mainstreaming.

Practical

Visits to rural institutions of women for studying in the rural institutions engaged in Women empowerment; Visits to entrepreneurial unit of women for studying the ways and means of establishing entrepreneurship units for Women and their development and also SWOT analysis of the Unit; Visit to Center for women development - NIRD to study the different activities related to projects and research on gender; Visit to gender cell, Office of the Commissioner and Director

of Agriculture, Hyderabad, to study the mainstreaming of gender concerns and gender budget of the department.

Suggested Readings

Grover I & Grover D. 2002. *Empowerment of Women*. Agrotech Publ. Academy.
Porter F, Smyth I & Sweetman C.1999. *Gender Works: Oxfarm Experience in Policy and Practice*. Oxfarm Publ.
Raj, MK. 1998. *Gender Population and Development*. Oxford Univ. Press.
Sahoo RK & Tripathy SN. 2006. *SHG and Women Empowerment*. Anmol Publ.
Sinha K. 2000. *Empowerment of Women in South Asia*. Association of Management Development Institution in South Asia, Hyderabad.
Thakur Joshi S. 1999. *Women and Development*. Mittal Publ.
Vishwanathan M. 1994. *Women in Agriculture & RD*. Rupa Books.
Himanshu, Sekhar Rout and Prasant Kumar Panda (Eds.). 2008. Gender and development in India. Dimensions and strategies. New Century Publications, New Delhi.
Krishna, Sumi (Ed.). 2007. Women's Livelihood Rights. Recasting Citizenship for Development. Sage. New Delhi.
IIPS. 2008. *National Family Health Survey (NFHS) -3 India*. Mumbai.
UNDP. 2009. Human Development Report 2009. Oxford University Press.
Government of India. National Human Development Report. (2001, or later). Planning Commission. New Delhi.

11.EXT 511 PERSPECTIVES OF DISTANCE EDUCATION 1+1

Objective

The course is intended for orienting the students with the concept of Distance Education, Characteristics of Distance Education, Evolution, Methods of Distance Education, Different Approaches in Planning Distance Education, Educational Technology in Distance Education, Management of Resources for distance education, Strategies for maximizing the reach and programme evaluation and quality assessment.

Theory

UNIT I

Distance Education – Introduction Meaning, Concept, Philosophy and its work ethics, characteristics of Distance Education – Evolution and Historical view of Distance Education – Theory Methodology, and Epistemology. Dimensions of Distance Education, Scope and difficulties. Open Education – Non-formal Education, Continuing Education, Education by correspondence.

UNIT II

Forms and systems of Distance and Open Education, Modes of Teaching and Learning in Distance Education, Methods of Distance Education, Significance of Distance Education in Teacher Education.

UNIT III

Planning Distance Education – A Systems Approach Student Learning – Course Planning, The target groups – Barriers to learning in Distance Education – Planning and Management of Networked Learning.

UNIT IV

Educational Technology in Distance Education Application of information and Educational Technologies in Distance Education, Development of Course and Course material, Management of resources, processes, Forms of Instructional material in Distance Education and Media Development and Production in Distance Education - Video Classroom Strategy in Distance Education – Strategies for maximizing the reach – services to students, programme Evaluation -
performance indicators and Quality Assessment.

Practical

Visit to the University which is implementing the Distance Education Programmes. Detailed Study of their programme in relation to Educational Technology, Methodology, Curriculum Development, Evaluation and Assessment. Exercise on development of curriculum for Distance Education exclusively for farming community.

Suggested Readings

Holmberg B. 1995. *Theory and Practice of Distance Education*. Routiedge Publ..

Lakshmi Reddy MV. 2001. *Towards Better Practices in Distance Education*.Kanishka Publ.

More MG. 2003. *Hand Book of Distance Education*.Lawrence Erlbaum Associates Publ.

Panda.S. 2003. *Planning & Management in Distance Education*. Kogan Page Publ.

Pathak CK. 2003. *Distance Education: Prospects and Constraints*. Rajat Publ.

Sharma DC. 2005. *Management of Distance Education*. Anmol Publ.

Sharma M. 2006. *Distance Education: Concepts and Principles*. Kanishka Publ.

12.EXT 512 MARKET-LED EXTENSION MANAGEMENT 1+1

Objective

The student will learn the significance of post harvest management& value addition in present market environment and the challenges and future strategy for market led extension management. Also identifies the information sources and develop strategy for market intelligence and the marketing infrastructure, multi-level marketing and linkages for market led extension. In addition the students would be learning the public private partnerships for market led extension management, the features of contract farming, WTO its implications on agriculture and Understanding the role of IT for market intelligence.

Theory

UNIT I

Agricultural extension at cross roads: Changing scenario of agricultural extension at the national level; Market led extension – emerging perspectives; Market led extension – issues and challenges; Dimensions of market led extension.

UNIT II

Agricultural marketing an overview; Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviour; Marketing communication and promotional strategies; The marketing research process; Agricultural trade liberalization and its impact; International marketing opportunities; Implications of AOA, TRIPS and IPRs agreements on agriculture; Agreement on SPS and TBT - an over view; Commodity features marketing.

UNIT III

Public private linkages in market led extension; Role of SHG in market-ledextension; Contract farming – a viable approach to meet market challenges; ITenabled approaches for market led extension and communication; Weather service and crop modeling – An effective tool in market-led extension.

Practical

Identification and analysis of different marketing sources for agricultural commodities. Development of strategy for an effective market intelligence system; Development of suitable marketing plan to suite rural situation; Visit to APEDA, Rythu Bazaars to study the processes and procedures related to market-led extension.

Suggested Readings

Kaleel FMH and Krisnamurthy J. 2007. *Market-led Extension Dimensions and Tools*. Agro Tech Publ. Academy.

Rajmanohar TP & Kumaravel KS. 2006. *Contract Farming in India*. ICFAI Univ.Press, Hyderabad.

Subbalakshmi V. 2005. *Globalization - Indian Experience*. ICFAI Univ. Press, Hyderabad.

Suresh K. 2005. *Rural Markets - Emerging Opportunities*. ICFAI Univ. Press,Hyderabad

Ph.D COURSES

1. EXT 601: ADVANCES IN AGRICULTURAL EXTENSION 2+1

Objective

By the end of the course, the student will be able to

• Critically analyze different Agricultural Extension approaches

• Understand Agricultural Knowledge Information System (AKISs), ITK

• Understand Advances in Extension - Cyber extension, ICT-enabled extension services;

Market-led Extension, Public - Private Partnership, Mainstreaming gender in extension organizational Innovations.

• Visualize implications of WTO - AOA and develop extension strategies.

• Understand extension reforms and Farmer Field Schools Decentralized Decision Making, bottom up planning, ATMA, FSBE & CIGs etc., ATIC, IVLP & Kisan Call Centres

Theory

UNIT I

Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS.

UNIT II

Cyber Extension - Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension, alternative methods of financing agricultural extension - Scope, limitations and experience and cases. Research - Extension -Farmer - Market linkage: Importance, Scope, Implications etc., Market - Led Extension, Farmer - Led Extension, Concept of Farm Field School, Farm School, Public - Private Partnership: Meaning, Models, Identification of various areas for partnership. Stakeholder's analysis in Extension. Main streaming gender in Extension - Issues and Prospects.

UNIT III

Implications of WTO: AOA for extension services, re-orientation of extensionservices for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension.

UNIT IV

Extension and contemporary issues: Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs). Extension Reforms in India - Decentralized decision making, Bottom up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups. Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres.

Practical

Analysis of ITK systems, cases on integration of ITK and formal research system, Analysis of cases on cyber extension and privatization of extension. Analysis of ATMA and SREP. Practicing bottom up planning. Visit to Public-Private –Farmer partnership. Learnings from Food and Nutritional Security and bio-diversity Projects and Programmes.

Suggested Readings

Bagchi J. 2007. *Agriculture and WTO Opportunity for India*. Sanskruti.

Chambers R, Pacy A & Thrupp LA. 1989. *Farmers First*. IntermediateTechnology Publ.
Crouch BR & Chamala S. 1981. *Extension Education and Rural Development*. Macmillan.
John KC, Sharma DK, Rajan CS & Singh C. 1997. *Farmers Participation inAgricultural Research and Extension Systems*. MANAGE, Concept Publ. Co.
Khan PM. 2002. *Text Book of Extension Education*. Himanshu Publ.
Narasaiah ML. 2005. *Agricultural Development and World Trade Organization*. Discovery Publ.
Talwar S. 2007. *WTO Intellectual Property Rights*. Serials Publ.
Van den Ban BW & Hawkins BS. 1998. *Agricultural Extension*. S.K. Jain Publ.
Venkaiah S. 2001. *New Dimensions of Extension Education*. Anmol Publ.

2.EXT 602 ADVANCED DESIGNS AND TECHNIQUES IN SOCIAL SCIENCE RESEARCH **2+1**

Objective

By the end of the course, the student will be able to

• Develop & Standardize Attitude scale using different techniques of attitude scale construction.

• Develop skills of using Projective and Semi-projective techniques, Analysis using various computer packages and PRA Tools in Extension Research.

Theory

UNIT I

Scaling technique - Importance, meaning, types, principles, steps and quality, techniques of attitude scale construction - Paired comparison, Equal appearing intervals, Successive Intervals, Summated ratings, Scalogram analysis, Scale discrimination technique, Reliability and Validity of Scales. Sociometry, content analysis, case studies, Q-sort techniques, Semantic different technique.

UNIT II

Projective and Semi-projective techniques; Critical incident techniques, Computer packages for analysis - usage in Extension Research. Knowledge scale measurement. Participatory tools and techniques in behaviour Research – Data collection and Evaluation. Impact analysis, e-data collection and information analysis.

Practical

Practice in constructing a scale and use of scale in various situations. Reliability and validity of the scales developed, Application of Semi Projective and Projective techniques. Content analysis, case studies. Practicing participatory tools and techniques. Hands on experience on Computer Preparation and Data Collection instruments, review of previous studies.

Suggested Readings

Burns RB. 2000. *Introduction to Research Methods*. Sage Publ.
Chandrakandan K & Karthikeyan C. 2004. *Behavioral Research Methodology*.Classical Publ.
Daivadeenam P. 2002. *Research Methodology in Extension Education*. Agro-Tech Publ. Academy.
Kerlinger N Fred. 2002. *Foundations of Behavioural Research*. Surjeet Publ.
Kothari CR. 2000. *Research Methodology Methods & Techniques*. 2nd Ed. Wishwa Prakasham.
Ray GL & Mondal S. 1999. *Research Methods in Social Science and Extension Education*. Naya Prokash.

Roger L & Domino WSK. 1980. *Research Methods*. Prentice Hall.
Sadhu AM & Singh A. 2003 *Research Methodology in Social Science*. Himalaya Publ. House.
Sarantakos S. 1998. *Social Research.* 2nd Ed. Macmillan.
Sinha SC & Dhiman AK. 2002. *Research Methodology*. ESS Publ.
Verma RK & Verma G. 2002. *Research Methodology*. Commonwealth Publ.
Walizer MH & Panl L. 2002. *Research Methods & Analysis; Searching forRelationships.* Wiemil Harper & Row.
Wilkinson TS & Bhandarkar PL. 2002. *Methodology and Techniques of SocialResearch*. Himalaya Publ. House.

3.EXT 603 ADVANCES IN TRAINING TECHNOLOGY 2+1

Objective

By the end of the Course student will be able to

- Plan and design a training programme
- Plan & Develop effective training sessions
- Manage difficult situations while organizing training programmes
- Use different advanced participatory training methods

Theory

UNIT I

Paradigm shift in training - learning scenario, Training Approaches – Experiential learning - laboratory - organization development (system) approaches; Training Design, Designing an effective training programme, Harmonizing training needs, Course Objective, content and methods.

UNIT II

Designing an effective training session: the semantics involved, Designingexperiential training sessions, simulation exercises, and openness in training transaction - managing dilemmas, ambivalence and conflicts and confusion (forboth trainers and trainees).

UNIT III

Recent Training Techniques: Understanding and facilitating team building,group dynamics, motivation and empowerment, laboratory methods: micro-lab process work, and sensitivity training, Psychological instruments as training tools: TAT, Inventories, Cases, etc.

UNIT IV

Participatory Training Techniques: Lecture, Brainstorming, Group discussion and Training Games. Role Play, Psycho-drama, Coaching, Counseling, etc., Trainer's roles and dilemmas, Factors Effecting Training Effectiveness and Training Evaluation.

Practical

Techniques of participatory training need assessment. Formulation of Course Objective, design of training programmes. Simulation exercises. Participatory training methods - Role Play & Brainstorming, Group discussion and Counseling and Conducting experiential learning sessions. Training evaluation - Techniques of Knowledge, Skill & Attitude evaluation. Visit to training institutions and study of training technologies followed.

Suggested Readings

Agochiya D. 2002. *Every Trainer's Handbook.* Sage Publ.
Alan B & Calardy 2004. *Five Case Studies in Management Training*. Jaico Publ.
Kumar A. 2000. *Management Training Process.* Anmol Publ.
Leslie Rae. 1998. *Techniques of Training*. Jaico Publ.
Lynton RP & Pareek U. 1999. *Training for Development*. 2nd Ed. Vistar Publ.

Reid MA. 1997. *Training Interventions, Managing Employee Development*. Jaico.Publ.
Samanta RK. 1993. *Training Methods for Management and Development*. M.D. Publ.
Sethy ED. 2003. *A Practical Hand Book on Training*. Anmol Publ.

4.EXT 604 ORGANIZATIONAL DEVELOPMENT 2+1

Objective

By the end of the course student will be able to

• Understand and study the Organization in terms of types, characteristics, needs, motives, organization behaviour, Organization Communication, Organization development and Individual behaviour in organization.

• To anlayse the factors effecting organizational effectiveness and distinguish between functional and non functional organization.

Theory

UNIT I

Introduction to organizations: Concept and Characteristics of organizations,Organizational Behvaiour - Context and concept - levels of organizations - formaland informal organizations, Theories of organizations: Nature of organizational theory - classical theories - features of Bureaucracy - administrative theory and Scientific management - Neo-classical theories - the human relations movement - modern theory.

UNIT II

Systems approach to study organization needs and motives - Attitude, values and ethical behaviour - alienation and work - work motivation - communication and interpersonal behaviour - organization communication - leadership behaviour -decision making, problem solving techniques - organizational climate – change proneness and resistance to change, Organizational change, Organizational structure - Process in organizing - Dimension of Motivation Climate.

UNIT III

Departmentation - Span of Management - Delegation of authority – Centralization and decentralization - line and staff organization - functional organization -divisonalisation - Project organization - Matrix organization - free form organization - top management structure.

UNIT IV

Individual behaviour in organization. Fundamentals of Human relations and Organizational behaviour, Groups and teams - Organisational culture and performance. Dynamics of Organization behaviour - leadership conflict situations and inter group behavior- Organisational Development - Factors effecting organization effectiveness. Creativity, leadership, motivation and organization development.

Practical

Analysis of organization in terms of process - attitudes and values, motivation,leadership. Simulation exercises on problem-solving - Study of organizational climate in different organizations. Study of organizational structure ofdevelopment departments, Study of departmentalization, span of control delegation of authority, decisions making patterns, Study of individual and group behaviour at work in an organization. Conflicts and their management in an organization. Comparative study of functional and non-functional organsiations and drawing factors for organizational effectiveness.

Suggested Readings

Ancona, Kochaw, Scully, Van Maanen, Westney 1999. *Organizational Behaviourand Processes*. South Western College Publ., New York.
Banerjee M. 1984. *Organizational Behaviour*. Allied Publ.
Deka GC. 1999. *Organizational Behaviour - A Conceptual ApplicationalApproach*. Kanishka Publ.
Dwivedi RS. 2006. *Human Relations and Organization Behaviour- A GlobalPerspective.* 5th Ed. Macmillan.
Kumar A. 2000. *Organizational Behaviour Theory and Practice*. Anmol Publ.
Luthans F. 1998. *Organizational Behavior*. Tata McGraw Hill.
Luthans F. 2001. *Organizational Behaviour*. McGraw Hill.
Newstrom JW & Davis K. 1997. *Human Behaviour at Work*. Tata McGraw Hill.
Robbins SP. 2007. *Organizational Behaviour*. Prentice Hall.
Shaun T & Jackson T. 2003. *The Essence of Organizational Behaviour*. Practice Hall of India.
Stephen RR. 1999. *Organizational Behaviour*. 5th Ed. Practice Hall of India.

5. EXT 605 ADVANCED INSTRUCTIONAL TECHNOLOGY 2+1

Objective

By the end of the course student will be able to

- Understand Agricultural Education Scenario in the country and Curriculumdevelopment process
- Plan & Prepare and present course outline, Lesson Plan & Skill plan
- Develop appropriate Teaching & Learning Styles
- Use innovative instructional aids & methods

Theory

UNIT I

Importance, Concepts and Scope of Instructional Technology. History of agricultural education in India. Guidelines for curriculum development in Agricultural Universities. Curriculum design development.

UNIT II

Course outline: Lesson plans for theory and practicals. Teaching and learning styles. Theories of learning. Cognitive levels. Instructional Course Objective.

UNIT III

Instructional Methods: Experiential learning cycle. Innovative Instructional Aids.Computer Assisted Instruction. Programmed instruction technique. Team Teaching. E-Learning, Art of Effective Communication. Distance education. Student evaluation - Question Bank. Appraisal of Teacher Performance. Review of research in Instructional Technology.

Practical

Formulation of instructional Course Objective. Development and presentation of course outlines. Preparation & presentation of lesson plans for theory & practicalwith CAI design. Preparation of innovative low cost instructional aids.Development of model question bank. Preparation of schedule for teacher evaluation. Visit to Distance Education centre. Study of research reviews and
Presentation of reports.

Suggested Readings

Agarwal JC. 2007. *Essentials of Educational Technology Innovations in Teaching – Learning*. 2nd Ed. Vikas Publ. House.

Agarwal R. 2000. *Educational Technology and Conceptual understanding*. Anmol Publ.
Dayal BK. 2005. *Educational Planning and Development*. Dominant Publ.
Grover I, Kaushik S, Yadav L & Varma SK. 2002. *Communication and Instructional Technology*. Agro Tech Publ. Academy.
Jacobsen D, Eggen P & Kauchak D. 1985. Methods for Teaching - A Skills Appraoch. 2nd Ed. Charles E. Merrill Publ.
Joyee B & Well M. 1980. *Models of Teaching*. 2nd Ed. Prentice Hall.
Khan PM. 2002. *Text Book of Extension Education*. Himanshu Publ.
Rush N. 1987. *Technology Based Learning - Selected Readings*. London Publ.Co., New York.
Tara Chand 1999. *Educational Technology*. Anmol Publ.

6. EXT 606 THEORY CONSTRUCTIONS IN SOCIAL SCIENCES 2+0

Objective

By the end of the course, the student will be able to develop skills of theory building and scientific application of theoretical concept in Social Sciences by applying appropriate statistical tests.

Theory

UNIT I

Importance of theory constructions in Social Science. Theory: Meaning, elements, Ideal Criteria, Functions, Types. Definitions: Meaning, types andRules.Generalizations: Meaning, Classification. Relationship: Meaning Types.

UNIT II

Terminologies used in theory constructions: Axiom, Postulate, Proposition,Theorem, Fact, Concept, Construct, Probability and Measurement Basic Derived.Steps in theory building - Axiomatic Techniques, Historical approaches. Scientific application Theoretical concept in Social Sciences. Test of Theory: Applying appropriate statistical tests.

Suggested Readings

Blalock HM. *Theory Construction: Form verbal to Mathematical Formulations*.Prentice Hall.
Dubin R. *Theory Building*. The Free Press, New York.
Gibbs JP. *Sociological Theory Construction*. The Dryden Press, Illionis.
Hage J. *Techniques and Problems of Theory Constructions in Sociology*. John Wiley & Sons
Stinchombe AL. *Construction of Sociological Theories*. Harcourt, Brace & World.
Wionton CA. *Theory and Measurement in Sociology*. John Wiley & Sons.

7 EXT 607 ADVANCED MANAGEMENT TECHNIQUES 2+1

Objective

By the end of the course student will be able to

• Develop understanding on concept of MIS, its scope in Agriculture Extension Organization.
• Understand, Develop and Evaluate the MBO System
• To cope up with stress, Resolve conflicts and develop effective inter personal communication skills using Transactional analysis.
• To plan and use DSS, AI, ES, PERT, CPM

Theory

UNIT I

Management Information System (MIS): Basic concepts, types of information needed at various levels, design of MIS in an agricultural extension organization. Scope for computerization, system alternatives and Evaluation. Implementation, operation and maintenance of the system.

UNIT II

Management by Objective (MBO): Elements of the MBO system. The Process of MBO. Making MBO effective. Evaluation of the MBO system - strengths and weaknesses. Transactional Analysis (TA): Ego states, transactions, inter relationships, strokes, stamps.

UNIT III

Managing Organizational Stress: Sources of stress in organization, effect of stress.Coping mechanisms and managing stress, Stress management, Team Building Process: Types of teams. Steps in teamwork, Facilitators and barriers to effective relationships, nature of prejudice, tips in reducing interpersonal conflicts, intergroup conflict, resolving techniques. Confect management, tips in reducing interpersonal conflicts.

UNIT IV

Decision Support Systems (DSSs): Basic information about Artificial Intelligence(AI) Expert System (ESs), their future applications in extension system.Forecasting techniques - time series analysis and Delphi, decision making and talent management PERT, CPM Techniques and time management.

Practical

Managements Information system, in research & development organizations. Study of Management by Course Objective in an organization. Transactional Analysis, exercises on Team building process, coping skills with organizational stress, exercises on Decision Support Systems (DSSs). Practicals exercise onforecasting techniques, Visit to Management organizations.

Suggested Readings

Chaudhary AK. 1999. *Encyclopedia of Management Information System*. Vols. I,II. Anmol Publ.

Hari Gopal K. 1995. *Conflict Management - Managing Interpersonal Conflict*. Oxford & IBH.

James O'Brien 1999. *Management Information System*. Tata McGraw-Hill.

Koontz H & Welhrich H. 2004. *Essentials of Management*. 5th Ed. Tata. McGraw-Hill.

Lauden & Lauden 2003. *Management Information System*. Pearson Edu.

Maheswari BL. 1980. *Organizational Decision Styles & Orgul Effectiveness*. Vikas Publ.

McGrath SJEH. 2007. *Basic Management Skills for All*. 7th Ed. Prentice Hall of India.

West JD & Leevy FK. 1998. *A Management Guide to PERT / CPM with GERT / PDM / DCPM and Other Networks*. Prentice Hall of India.

8. EXT 608 MEDIA MANAGEMENT 2+1

Objective

• To familiarize the students with the working of print, electronic, New Media and traditional folk media.

• To develop working skills needed for Print, Radio and T.V. Journalism to reach farming community.

• To develop in students an understanding on Mass Communication Process and Media Management its impact on the society.
• To develop writing skills for different media.

Theory

UNIT I

Media Management: Introduction, Definition, Principles and Significance of Management. Media Ownership patterns in India – Proprietorship, Partnership,private Ltd, Public companies, Trusts, Co-operatives, Religious Institutions (Societies) & Franchisees (Chains). Marketing Function – Product, Price, and Placement & Promotions.

UNIT II

Mass Communication: Meaning, Concept, Definition and Theories of Mass Communication. The Mass Media – History, functions, uses and Theories of Media. Journalism – Meaning, definition, Scope, functions and different types of Journalism. Journalism as communication tool. Farm Journalism – meaning and Developments in Farm Journalism in India. Different problems with Farm Journalism. Print Media – History, the role of the press, news, Types of News, electronics of News and Sources of News, the making of newspaper & magazines, press codes and ethics, Media Laws. News story – Principles of writing, structure a news story, procedure in writing the news story and the elements of style. Success stories & feature articles – writing for success & feature articles, Types of Feature articles. Information materials – Types of information materials and user.Techniques in book Publishing. Editing – Principles, Tools & Techniques and art of Proof Reading – Techniques, Measuring Readability of writing.

UNIT III

Electronic Media-Role and Importance of Radio -History, Radio Role in TOT,writing and presentation techniques, Different Programmes of Farm Broadcast,developing content for farm broadcast, Role of FM Radio in Agriculture, Ethics of Broad casting, Broadcasting Policy and code. Community Radio – Concept,meaning, role in TOT, Cases of Community radio. Television – History - Role in TOT , Fundamentals of Television Production, Techniques of Script writing for TV, Visual Thinking, language & Style, Farm Telecast programmes, cable and satellite TV and their impact, Ethics of Telecasting, policy and code. Video Production Technology **–** Potential and its utilization, Typology of farmVideo production, Types of Video Production and equipment used in the production, Procedure or Technique of video production. Cassette Technology – Role in TOT, Techniques of production of cassettes for the farming community. Traditional Media – Role of Folk Media in TOT and integration with electronic media.

UNIT IV

Advances in communication Technology: Management of Agricultural Information System (MAIS). Use of computers in Agriculture – Application of ITin Agriculture. Use of Modern Communication Medium- Electronic Video, Teletext, tele conference, Computer assisted instruction, Video conferencing, - Features, Advantages, Limitations and risk factory involved in New Media. Designing and developing of communication and media strategy for developmental programmes. Online journalism scope & importance.

Practical

Exercise on Writing for Print Media – Writing News / Success Stories / Feature articles for different topics related to Agriculture & allied fields. Exercise of editing & proof reading the Farm News for News papers – different types of intro and leads. Exercise of Writing for Radio, TV, Preparation of story board for farm Video Production – Script

writing for Radio and T.V. Visit to media managementorganizations for studying the principles, procedures and processes in managing the media. Participation and Interaction through video conference. Developing communication & Media Strategy for selected developmental programme / activity.

Suggested Readings

Bhaskaran C., Prakash, R. and Kishore Kumar N. 2008. *Farm Journalism in Media Management*. Agro-Tech Publ. Academy.

Chattergee PC. 1991. *Broadcasting in India*. Sage Publ.

Chiranjeev A. 1999. *Electronic Media Management*. Authors Press.

D'Souza YK.1998. *Principles and Ethics of Journalism and MassCommunication*. Commonwealth Publ.

Defleur ML & Dennis EE. 2001. *Understanding Mass Communications*. Goyalsaab Publ.

Jain SC. 2006. *International Marketing Management*. CBS Publ.

Keval J Kumar. 2004. *Mass Communication in India.* Jaico Publ.

Malhan PN. 2004. *Communication Media: Yesterday, Today and Tommorow*.Directorate of Publication Division, New Delhi.

Mehta DS. 1992. *Mass Communication and Journalism in India*. Allied Publ.

Panigrahy D. 1993. *Media Management in India*. P. K. Biswasroy (Ed.). Kanishka Publ.

Shrivastava KM. 1995. *News Writing for Radio and TV*. Sterling Publ.

Sinha KK. 2001. *Business Communications*. Galgotia Publ.

9. EXT 609 TRANSFER OF TECHNOLOGY IN AGRICULTURE 2+1

Objective

By the end of the Course student will be able to

• Develop thorough understanding on different systems of Technology Transfer

• Develop appropriate communication & Media Strategy suitable to the System of Technology Transfer

• Analyse the constraints in Systems of Technology Transfer Technology and suggest suitable Strategies.

Theory

UNIT I

Technology - Meaning and Concepts - Appropriate technology, transfer of technology - meaning and concepts. Systems of transfer of technology -Knowledge Generating System (KGS) - Knowledge Disseminating System (KDS)- Knowledge Consuming System (KCS) - Input Supplying Agencies System (ISAS).

UNIT II

Appropriateness of communication media in the system of technology transfer.New communication strategy for transfer and adoption of Agricultural technology. Extension training in transfer of technology.

UNIT III

Analysis. Constraints in Transfer of Technology, agencies or departments involved in TOT. Extension professional in TOT. Attributes of Technology and its Relation in TOT process. TOT to resource poor farmers. Role of Key communicators or local leaders in TOT. Private and Public partnership in TOT.

Practical

Analysis of Transferred technology. Analysis of knowledge generation and consuming systems. Formulation of communication strategies, Study of attributesof selected fast spreading technologies and slow technologies, study of constraintsin TOT, visit to TOT

centres of ICAR and SAU, Identification of key communicators, Case studies of Public-Private Partnerships, Visits to the print and electronic media centres to study their role in TOT.

Suggested Readings

Chaturvedi TN. 1982. *Transfer of Technology among Developing Countries; Needfor Strengthening Cooperation*. Gitanjali Publ. House.

Dunn DD. 1978. *Appropriate Technology With a Human Face*. Macmillan Press.

Kapoor SK, Roy PB and Roy AK. 1980. *Role of Information Centres in TechnologyTransfer*. IASLIC, Kolakata.

Lekhi RK. 1984. *Technological Revolution in Agriculture*. Classical Publ. Co.

Singh SN. 1991. *Transfer of Technology to Small Farmers; An Analysis of Constraints and Experience*. Concept Publ. Co.

Wallender HW. 1980. *Technology Transfer of Management in the DevelopingCountries*. Ballinger Publ. Co., Cambridge.

List of Journals

- Agricultural Extension Review
- European Journal of Agricultural Education and Extension
- Indian Journal of Social Work
- International Journal of Business and Globalization
- International Journal of Sustainable Development
- Journal of Extension
- Journal of Asia Entrepreneurship and Sustainability
- Journal of Environmental Extension
- Journal of Extension Education
- Journal of International Agriculture and Extension Education
- Journal of Rural Development
- British Journal of Educational Technology
- Economic and Political Weekly
- Indian Economic Panorama
- Indian Journal of Adult Education
- Indian Journal of Extension Education
- Indian Journal of Human Development
- Indian Journal of Open Learning
- Indian Journal of Social Development
- Indian Journal of Training and Development
- Indian Social Science Review
- Journal of Extension System
- Journal of Development Studies
- Journal of Educational Planning and Administration
- Journal of Educational Psychology
- Journal of Environmental Studies and Policy
- Journal of Sustainable Agriculture
- The Journal of Entrepreneurship

e- Resources

- www.pearsoned.com (Pearson Education Publication)
- www.mcgraw-hill.com (McGraw-Hill Publishing Company)
- www.oup.com (Oxford University Press)
- www.emeraldinsight.com (Emerald Group Publishing)
- www.sagepub.com (Sage publications)

- www.macmillanindia.com (Macmillan Publishing)
- www.krishiworld.com (Agriculture Portal)
- www.aiaee.org (The Association for International Agricultural and Extension Education)
- www.geogate.org (Agriculture Portal)
- www.icar.org.in (Indian Council of Agricultural Research)
- www.manage.gov.in (National Institute of Agricultural Extension Management)

Suggested Broad Topics for Master's and Doctoral Research

- Agricultural communication
- Agricultural Journalism
- Agriculture Education
- Agro Forestry Extension
- Banking & Credit
- Commercialization and Diversification in Agriculture
- Vegetables
- Horticulture
- Agri. tourism
- Floriculture
- Mushroom cultivation
- Bee Keeping
- Organic Farming
- Cropping System/Farming System
- Diffusion and Adoption
- Dry Farming Technology
- Entrepreneurship Development
- Extension Administration and Management
- Extension Methods and techniques
- Extension Trainings
- Extension Management and Sustainable Agricultural Development
- Indigenous Practices
- Rural Organization and Institutions
- Scientific Productivity and Human Resource Development
- Youth/Women Development
- Social Marketing

X PLANT PHYSIOLOGY

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
PP 501*	PRINCIPLES OF PLANT PHYSIOLOGY- 1	2+1
PP 502*	PLANT DEVELOPMENTAL BIOLOGY – PHYSIOLOGICAL AND MOLECULAR BASIS	2+0
PP 503*	PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES	2+1
PP 504*	HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT	2+1
PP 506*	PHYSIOLOGY OF GROWTH , YIELD AND MODELING	1+1
PP 507	GENOME ORGANIZATION IN HIGHER PLANTS	2+1
PP 508*	MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION	2+1
PP 509	PHYSIOLOGY OF CROP PLANTS –SPECIFIC CASE STUDIES	2+0
PP 510	PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS- CARBON AND NITROGEN ASSIMILATION	2+1
PP 511	MINERAL NUTRITION	2+1
PP 512	PRINCIPLES OF PLANT PHYSIOLOGY -II	2+1
PP 591	MASTER'S SEMINAR	1+0
PP 591	MASTER'S SEMINAR	0+1
PP 599	MASTER'S RESEARCH	20
	Ph.D COURSES	
PP 601**	FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES	2+0
PP602**	SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES	2+0
PP 603**	MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS	2+1
PP 604	TECHNIQUES IN PLANT PHYSIOLOGY	1+2
PP 605	CLIMATE CHANGE AND CROP GROWTH	2+0
PP 606	POST HARVEST PHYSIOLOGY	2+0
PP 607	WEED PHYSIOLOGY AND HERBICIDE ACTION	1+1
PP 608	SEED PHYSIOLOGY	2+1
PP 691	DOCTORAL SEMINAR I	0+1
PP 692	DOCTORAL SEMINAR II	0+1
PP 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme;

Supporting Courses (compulsory) 5 CREDITS

SOILS 508 RADIO ISOTOPES IN SOIL AND PLANT STUDIES 1+1

STAT 512 DESIGN OF EXPERIMENTS

** Compulsory for Ph. D. programme

1. PP 501 PRINCIPLES OF PLANT PHYSIOLOGY - I 2+1

Objective

To acquaint the students with the basic concepts of water relations and mineral nutrition and their application in agriculture.

Theory

UNIT I

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.

UNIT II

Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells.

UNIT III

Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants – Mycorhizal association on water uptake.

UNIT IV

Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpiration –Driving force for transpiration, plant factors influencing transpiration rate.

UNIT V

Stomata structure and function – mechanism of stomatal movement, antitranspirants.

UNIT VI

Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

UNIT VII

The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants.

UNIT VIII

Physiological and metabolic functions of mineral elements, critical levels,deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition

UNIT IX

Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants.

Practical

Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe, Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test. Theory and principle of pressure bomb, psychrometer and osmometer, Measurement of transpiration rate. Measurement of vapour pressure deficits, theory and principle of porometry, diffusion prometer and Steady state porometer, Stomatal physiology, influence of ABA on stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiency symptoms of nutrients

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C. 1992. *Plant Physiology.* 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

2.PP 502 PLANT DEVELOPMENTAL BIOLOGY – PHYSIOLOGICAL AND MOLECULAR BASIS 2+0

Objective

To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

Theory

UNIT I

Plant Biodiversity, Concept of evolution in plants.

UNIT II

General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth.

UNIT III

Seed Germination and Seedling Growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth.

UNIT IV

Shoot, Leaf and Root Development – Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages.

UNIT V

Floral Induction and Development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination.

UNIT VI

Seed Development and Dormancy – Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy.

UNIT VII

Senescence and Programmed Cell Death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

UNIT VIII

Light Control of Plant Development – Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants

UNIT IX

Embryonic Pattern Formation – Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants.

UNIT X

Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize.

UNIT XI

Special Aspects of Plant Development and Differentiation – Pollen germination and pollen tube guidance; Phloem differentiation; Sex determination in plants;

UNIT XII

Self-incompatibility and its genetic control; Heterosis and apomixis.

Suggested Readings

Kabita Datta 2007. *Plant Physiology*. Mittal Publ.

Srivastava L.M. 2002. *Plant Growth and Development: Hormones and Environment.* Academic Press.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.
Wareing PF & Phillips IDJ. 1981. *Growth and Differentiation in Plants*. 3rd Ed.Pergamon Press.
Wilkins MB. 1969. *Physiology of Plant Growth and Development.* Tata McGraw-Hill.

3.PP 503 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES 2+1

Objective

To apprise the students regarding abiotic stress to plant and its molecular basis.

Theory

UNIT I

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses.

UNIT II

Drought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept.

UNIT III

Transpiration and its regulation – stomatal functions.

UNIT IV

Physiological processes affected by drought. Drought resistance mechanisms: Escape, Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait.

UNIT V

Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products.

UNIT VI

Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.).

UNIT VII

High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's.

UNIT VIII

Chilling stress: Effects on physiological processes. Crucial role of membrane lipids.

UNIT IX

Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, Breeding for salt resistance.

UNIT X

Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

Practical

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Determination of soil water potential and content by psychrometry and other systems. Stress imposition and quantification, Stress –stomatal conductance. Canopy temperature as a reflection of transpiration and root activity, Water use – efficiency, Determination at whole plant and single leaf level, Root- shoot signals-ABA and cytokinin effect on stomatal behavior, Heat tolerance and

membrane integrity. Sullivans heat tolerance test, chilling tolerance- Galactolipase and free fatty acid levels as biochemical markers for chilling damage, Cold induced inactivation of O2 evolution of chloroplasts- as a screening technique for chilling tolerance.

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
Salisbury FB & Ross C. 1992. *Plant Physiology.* 4th Ed. Wadsworth Publ.
Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

4.PP 504 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT 2+1

Objective

To apprise the students about the function of plant growth regulator on growth and development of plant.

Theory

UNIT I

Definition and classifiacation of palnt growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. tricontanol, Phenols – polyamines, jasmonates, concept of death hormone.

UNIT II

Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberllins, cytokinins, Abscisic acid and Ethylene Brassinosteroids.

UNIT III

Hormone mutants and transgenic plants in understanding role of hormones.

UNIT IV

Signal perception.transduction, and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins -, germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plant parts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening.

UNIT V

Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development.

UNIT VI

Synthetic growth regulators- Classification, their effect on plant growth and development.

Practical

Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect on rooting of cuttings, abscission, apical dominance, Gibberellins- bioassays-GA effect on germination of dormant seeds, cytokinin- bioassays- estimation using immunoassay technique cytokinin effect on apical dormance and senescence, ABA bio assays estimation using immunoassay technique. ABA effect on somatal movement, Ethylene bioassays, estimation using physico chemical techniques- Use of hormones in breaking dormancy .

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
Salisbury FB & Ross C. 1992.*Plant Physiology*. 4th Ed. Wadsworth Publ.
Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

5.PP 506 PHYSIOLOGY OF GROWTH, YIELD AND MODELING 1+1

Objective

To impart knowledge regarding crop growth analysis and different yield prediction models.

Theory

UNIT I

Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity- the concept of rate limitation

UNIT II

Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration.

UNIT III

Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI.

UNIT IV

Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index.

UNIT V

Plant growth analysis techniques, yield structure analysis, theoretical and actual yields.

UNIT VI

Plant ideotypes,

UNIT VII

Simple physiological yield models- Duncan's. Monteith's, and Passioura's

UNIT VIII

Crop growth models-empirical models testing and yield prediction.

Practical

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA partitioning efficiency ,HI, Measurement of light interception, light extinction coefficient, energy utilization efficiency based on energy intercepted, and realized, Computer applications in plant physiology, crop productivity and
modeling.

Suggested Readings

Gardner FP, Pearce RB & Mitchell RL. 1988. *Physiology of Crop Plants*. Scientific Publ.

Goudriaan J & Van Laar HH. 1995. *Modelling Potential Crop Growth Processes.* (Textbook with Exercises) Series: *Current Issues in Production Ecology.* Vol. II. Kluwer.

Hunt R. *Plant Growth Curve - The Fundamental Approach to Plant Growth Analysis*. Edward Arnold.

John H, Thornley M & Johnson IR. *Plant and Crop Modeling: AMathematical Approach to Plant and Crop Physiology*. Blackburn Press.

Vos J, Marcelis LFM, Visser PHBD, Struik PC & Evers JB. (Eds.). 2007. *Functional-Structural Plant Modelling in Crop Production.* Vol. XXII. Springer.

6.PP 507 GENOME ORGANIZATION IN HIGHER PLANTS 2+1

Objective

To impart basic concept on genome organization in prokaryotic and eukaryotic system

Theory

UNIT I

Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, autoptetraploids and polyploids.

UNIT II

Gene & gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokayotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept.

UNIT III

Mitochondrial and chloroplastic genome organization and regulation of gene expression.

UNIT IV

Eukaryotic genome structure: Organization and replication; control of gene expression-transcription and post-transcriptional; promoter analysis; concept of cis elements; transcription factors, function and role of RNA polymerases.

UNIT V

Genetic code and translation-deciphering the genetic code; Codon bias; tRNAs, ribosomes; Initiation and termination of translation; Translational and post-translational controls; Attenuation ; Suppressor tRNAs.

UNIT IV

Mobile genetic elements; Structure and function of transposable elements; Mechanism of transposition; Special features of retro transposans; Repair and recombination

Practical

Culturing and transformation of bacteria; genomic DNA and plasmid DNA isolation from bacteria, restriction enzyme digestion and analysis by agarose gel electrophoresis, isolation of genomic DNA and RNA from plants and quantification; Culture of bacteriophage; studis on lytic and lysogenic phages.

Suggested Readings

Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts & Peter Walter. *Molecular Biology of the Cell*. 3rd Ed. Garland Science.

7.PP 508 MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION 2+1

Objective

To impart knowledge about cellular basic of growth and morphogenesis in Plants.

Theory

UNIT I

Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation.

UNIT II

The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency.

UNIT III
Introduction to in vitro methods : Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country (ovary and ovule culture , in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids.
UNIT IV
Introduction to the processes of embryogenesis and organogenesis and their practical applications : Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot – tip and meristem culture. Haploids and their applications. Somaclonal variations and applications (treasure your exceptions).
UNIT V
Introduction to protoplast isolation : Principles and applications . Testing of viability of isolated protoplast . Various steps in the regeneration of protoplast . Somatic hybridization – an introduction, Various methods for fusing protoplast, chemical and electrical . Use of makers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids)
UNIT VI
Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introdiuction to *A. tumefaciens*. Tumour formation on plants using *A. tumefaciens* (Monocots vs Dicots), Root – formation using *A.rhizogenes*

Practical

In vitro culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethlyne on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

Suggested Readings

Bajaj YPS. (Ed.). 1991. *Biotechnology in Agriculture and Forestry*. Vol.XIV. Springer-Verlag.
Rajdan MK. 1993. *Plant Tissue Culture*. Oxford & IBH.

8.PP 509 PHYSIOLOGY OF CROP PLANTS – SPECIFIC CASE STUDIES 2+0

Objective

To impart knowledge of physiological aspects of different crop plants.

Theory

UNIT I
Crop physiological aspects of rice, wheat, maize, sorghum,millets sugarcane, pulses, oil seeds, cotton and potato Crops.
UNIT II
Crop specific topics-
Rice,Cowpea,Sesamum,Tapioca,Coconut,Mango,Banana,Ginger,Turmeric, Pepper
UNIT III
Seed dormancy, photoperiodic and thermoperiodic responses.
UNIT IV
Source-sink relationship, Yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

Suggested Readings

Gardner FP, Pearce RB & Mitchell RL. 1988. *Physiology of Crop Plants*. Scientific Publ.

Pessarakli M. *Handbook of Plant and Crop Physiology*. CRC Press.
Selected reviews and articles from Periodicals and Journals.

9.PP 510 PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS-CARBON AND NITROGEN ASSIMILATION 2+1

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory

UNIT I

Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere.

UNIT II

Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield.

UNIT III

Photosynthetic carbon reduction cycle and its regulation. CO2 Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C4, CAM and single celled C4 organisms, C3-C4 intermediates. Ecological significance of CCM.

UNIT IV

Rubisco structure, assembly and kinetics, photorespiration and its significance.

UNIT V

Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of ra, rs and rm. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc.

UNIT VI

Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity – transgenics. Conceptual approaches of expressing C4 photosynthesis genes in C3 species.

UNIT VII

Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and no-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept.

UNIT VIII

Prospects of improving photo synthetic rate and productivity – potential traits of photosynthesis- biotechnological approaches.

UNIT IX

Nitrogen assimilation in photosynthesizing cells – NO3,-, NO2- reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its reassimilation and NUE.

Practical

Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O2 evolution, Determination of rubisco content (western and ELISA), activity and activation state, Enzymatic determination of starch and sucrose, Determination of

photosynthetic rates – WUE by gas exchange rates. Light, CO2, VPD response curves, Determination of photorespiration by gas exchange- (TPSAPS).Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception, Determination of NH4+, reduction of inorganic nitrogen species.

Suggested Readings

Edwin Oxlade & Graham Lawler. *Plant Physiology: The Structureof Plants Explained.* John Wiley & Sons.

Hopkins WG & Huner NPA.2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C.1992. *Plant Physiology.* 4th Ed. Wadsworth Publ.91

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

10.PP 511 MINERAL NUTRITION 2+1

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation

Theory

UNIT I

Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system.

UNIT II

Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.

UNIT III

Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation.

UNIT IV

Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels.

UNIT V

Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties.

UNIT VI

Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practical

Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities.

Suggested Readings

Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition*. CRC

Epstein E. 2007. *Mineral Nutrition of Plants*. John Wiley & Sons.

Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press.

11. PP 51 2 PRINCIPLES OF PLANT PHYSIOLOGY - II 2+1

Objective

To acquaint the students with the basic concepts in plant metabolic processes and growth regulation**.**

Theory

UNIT I

Photochemical process, photochemical reactions, CO2 reduction in Calvin cycle, supplementary pathway of C fixation in C4 and CAM plants and its significance.

UNIT II

Photorespiration and its relevance. Photosynthesis as a diffusive process- effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth

UNIT III

Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance

UNIT IV

Nitrogen metabolism: Inorganic nitrogen species (N2, NO3 and NH3) and their reduction to aminoacids, protein synthesis and nucleic acids.

Unit V

Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fattyacids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defence mechanism.

UNIT VI

Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominanace, senescence, fruit growth, abscission.

UNIT VII

Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering- Photoperiodism and Vernalisation.

Practical

Radiant energy measurements, separation and quantification of chlorophylls, O2 evolution during photosynthesis, Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Respiration rates, Estimation of reducing sugars, starch. Estimation of NO3, free amin oacids in the xylem exudates, quantification of soluble proteins. Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene. Demonstration of photoperiodic response of plants in terms of flowering.

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C. 1992. *Plant Physiology.* 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer A

Ph.D. COURSES

1.PP 601 FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES 2+0

Objective

To impart knowledge about physiological process of plant at molecular level.

Theory

UNIT I

Gene discovery: Finding Genes in Complex Plant System, Constructing Gene-Enriched Plant Genomic Libraries, In Silico Prediction of plant Gene Function, Quantitative Trait Locus Analysis as a Gene Discovery Tool

UNIT II

Genetic tools for plant development- Understanding the importance of mutants in unraveling the physiological processes – T-DNA insertion mutants, Gain in function, Transposon mutagens, Transposition, Physical and Chemical mutagenesis, Gene and Enhancer Traps for Gene Discovery, High-Throughput TAIL-PCR as a Tool to identify DNA Flanking insertions, High-Throughput TILLING for functional Genomics.

UNIT III

Gene knock out approaches: Antisense technology, Virus induced gene silencing (VIGS), Custom Knock-outs with Haripin RNA-mediated Gene Silencing and other silencing tools, Complementation studies, DNA micro arrays.

UNIT IV

Gene Over expression approaches: Vector Construction for Gene Overexpression as a Tool to Elucidate Gene Function; Transient expression, Transgenics.

UNIT VI

Proteomics: Networking of Biotechnology for interpreting gene functions. Yeast two hybrid systems to study protein –protein interaction to study gene functions, Proteomics as a Functional Genomics Tool, Crystallographic and NMR approaches to determine protein structures.

UNIT VII

Functional characterization of genes associated with important cellular processes influencing crop growth and development.

UNIT VIII

Case studies of genes controlling photosynthesis, respiration, photorespiration, fatty acid biosynthesis, nutrient uptake, flowering, seed protein quality and quantity.

Suggested Readings

Selected articles from various journals

2.PP 602 SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES 2+0

Objective

To impart the knowledge about signal ling of hormones and regulation of physiological processes.

Theory

UNIT I

General aspects: Introduction to signaling-Long range (Diffusible) signaling and short range (contact) signaling. Components of signaling- Upstream components: receptor and ligands concept-types of ligands and its relevance-receptor kinases-Two component sensing system. Down stream components: G. proteins-second messengers-

Cyclic AMP, adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-Kinases-Effector molecules (transcription factor).

UNIT II

Hormone signaling: Hormone binding receptors-Transduction process. Effector molecules and gene expression.

UNIT III

Specific signaling pathways of Auxins, Cytokinisn, Gibberllins, Ethylene, ABA, Brassinosteroids which leads to formative effects. The cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

UNIT IV

Light signaling: Perception of light-pigments involved-activation of phytochrome /cryptochrome (study of mutants). Light signal transduction- Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

UNIT V

Abiotic stress signaling: Sensing of environmental factors (Temperature- Osmoticum-Ionic stress) Activation of specific molecules and secondary messengers-Activation of Down stream components-leading to stress gene expression. Case studies with different abiotic stresses.

UNIT VI

Cross talk between signaling pathways.

UNIT VII

Signal perception and transduction in plant defense responses: Role of salicylic acid and active oxygen species.

UNIT VIII

Signaling cascade during leaf senescence, abscission, flowering and tuberisation

UNIT IX

Transcription factor as signaling regulatory tools for improving growth processes-Case studies: Tbi- lateral branch development, Shi 4- grain shattering, GA1-Dwarfing.MADS, KNOX- flowering development, HAT 4- Shade development, AP2-EREBP- biotic/abiotic stresses.

Suggested Readings

Selected articles from various journals.

3.PP 603 MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS 2+1

Objective

To impart knowledge to improve the physiological traits using molecular approaches.

Theory

UNIT I

Importance of Molecular Breeding for complex multi-gene controlled physiological traits and its relevance in augmenting trait based breeding.Physiological traits with relevance to growth, development, abiotic stress tolerance, nutrient acquisition, Approaches for accurate phenotyping of large germplasm accessions and/or mapping populations.

UNIT II

The advantages of “Trait based” breeding approaches. Concept of segregation, independent assortment and linkage. The concept of molecular markers, various types of Dominant and Co-dominant marker systems.

UNIT III
Relevance and development of mapping populations and genetic analysis using marker systems. Advantages of association mapping and the concept of linkage, LD decay and population structure.
UNIT IV
Statistical analysis to assess the variance in phenotypic traits and molecular data. Assessment of genetic parameters such as heritability, genetic advance etc.
UNIT V
Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining
UNIT VI
Transgenic approach in improving physiological processes- Introduction to GMOs and application in crop improvement; gene mining, sequence structure & function analysis using bioinformatics tools, identification of candidate genes for various physiological process associated with specific traits (such as stress tolerance) and their potential benefits in transgenic crops.
UNIT VII
Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make constructs for specific crops, gene stacking strategies, tissue specific expression and functional validation of genes.
UNIT VIII
Transformation of crop plants-*Agrobacterium* and use of other organisms for transformation-particle gun transformation and other methods.
UNIT IX
Selection of transformants- molecular analysis on the basis of qRT-PCR, Southern, Northern analysis and immunoassays; estimation of copy number. Concept of desirable number of independent events.
UNIT X
Evaluation of transgenics on basis of empirical/physiological/biochemical process under specific conditions on the basis of gene function. Generation of T1 populations, event characterization and generation of molecular data as per the regulatory requirements.
UNIT XI
Issues related to Biosafety and Registration of Transgenic Agricultural Organisms, methods to detect GMOs from agricultural products.

Practical

Phenotyping approaches for the different physiological traits. Genotyping options using gene-scan systems. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping using a DNA sequencing machine, scoring of gels and assessment of polymorphism, Statistical approaches to assess genetic variability, heritability and other parameters, Phylogenic analysis, Principal component analysis and construction of dendrograms. Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs, Bioinformatics – sequence analysis, structure analysis, Molecular biology - genomic/plasmid DNA isolation, RNA isolation. Full-length gene cloning, vector construction with specific promoter, gene stacking & transient assays. Transformation in model system,Crop transformation - *Agrobacterium* mediated transformation (inplanta & invitro), particle-gun transformation, Evaluation of transgenics – semiquantitative & quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene & testing LOD.

Suggested Readings
Selected articles from various journals will be issued separately at the beginning of course.

4.PP 604 TECHNIQUES IN PLANT PHYSIOLOGY 1+2

Objective
To impart recent practical training to study various physiological processes in plants.
Theory
UNIT I
Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements.
UNIT II
Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes.
UNIT III
Radio isotopes in plant biology.
UNIT IV
Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants, such as (a) DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; (b) techniques for defined physiological processes.
UNIT V
Methods to phenotype germplasm for specific physiological traits.
UNIT VI
Quantification of mineral nutrients using advanced instruments like AAS,
& ICP.
UNIT VII
Techniques in plant transformation & analysis of transgenic plants
UNIT VIII
Molecular markers- genetic distance and mapping population concept of linkage maps and identification of QTLS.
UNIT IX
Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phosphor-imager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.
Practical
Photosynthetic gas exchange measurements, light and CO2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements. Estimation of water use efficiency at plant and single leaf level. Use of stable and radioactive isotopes to understand physiological processes. Chromatographic techniques in Plant physiology, Quantification of mineral nutrients using advanced instruments like AAS.
Suggested Readings
Dhopte MA & Manuael Livera M. 1986. *Useful Techniques for Plant Scientists*. Forum for Plant Physiologists, R. D. G., Aloka.

5.PP 605 CLIMATE CHANGE AND CROP GROWTH 2+0

Objective

To impart knowledge about climate change and its implication to crop growth.

Theory

UNIT I

History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability.

UNIT II

Natural and anthropogenic activities and agricultural practices on GHG production, Monitoring of greenhouse gases and their influence on global warming and climate change, Ozone depletion leading to increased ionizing radiations and its implications on crop growth.

UNIT III

Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply.

UNIT IV

Approaches to mitigate climate change through studies on plant responses.

UNIT V

Direct and indirect effects of climate change on plant processes – phenology, net carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield.

UNIT VI

Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments

UNIT VII

International conventions and global initiatives on Carbon sequestration, carbon trading.

Suggested Readings

Abrol YP & Gadgil S. (Eds.). 1999. *Rice in a Changing Climate*.

Reddy KR & Hodges HF. 2000. *Climate Change and Global Crop Productivity.* CABI.

Watson RT, Zinyowera MC & Moss RH. 1998. *The Regional Impacts of Climate Change - an Assessment of Vulnerability.* Cambridge Univ.Press.

6.PP 606 POST HARVEST PHYSIOLOGY 2+0

Objective

To impart knowledge about physiological changes during senescence and ripening.

Theory

UNIT I

Environmental factors influencing senescence, ripening and post harvest life of flowers, vegetables and seeds.

UNIT II

Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening.

UNIT III

Senescence associated genes and gene products.

UNIT IV

Functional and ultrastructural changes in chloroplast membranes,mitochondria and cell wall during senescence and ripening.

UNIT V
Regulatory role of ethylene in senescence and ripening, ethylene biosynthesis, perception and molecular mechanism of action.
UNIT VI
Post harvest changes in seed and tubers biochemical constituent's quality parameters. Effect of environmental factors on post harvest changes in seed and tubers.
UNIT VII
Biotechnological approaches to manipulate ethylene biosynthesis and action.
UNIT VIII
Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life of flowers and fruits.
UNIT IX
Uses of GM crops and ecological risk assessment.

Suggested Readings

Jeffrey K Brecht & Weichmann J. 2003**.** *Post Harvest Physiology and Pathology of Vegetables.* CRC Press.

7.PP 607 WEED PHYSIOLOGY AND HERBICIDE ACTION 1+1

Objective

To apprise students regarding weed and crop competition, and physiological and molecular aspects of herbicides.

Theory

UNIT I
Weed biology, ecology and physiology. Weed and crop competition, allelochemicals, their nature and impact. Weed-seed physiology.
UNIT II
Classification of herbicides and selectivity. Recent concepts on entry, uptake, translocation and metabolism of soil and foliar applied herbicides.Environmental and plant factors influencing entry, uptake and translocation of herbicides.
UNIT III
Classification and chemistry of common herbicides. Physiological, biochemical and molecular mechanism of action of different groups ofherbicides; ACC synthase inhibitors, ALS inhibitors, Mitotic inhibitors, Cellulose biosynthesis inhibitors, Inhibitors of fatty acid biosynthesis, inhibitors of Photosynthesis, Auxinic Herbicides, New herbicides,
UNIT IV
Metabolic pathway of herbicide degradation in plants and soil. Herbicide adjuvants and their classification.
UNIT V
Molecular mechanism of action of herbicide synergists and antagonists.
UNIT VI
Physiological and molecular mechanism of herbicide selectivity.
UNIT VII
Herbicide resistant crops; transgenic & tissue culture approaches to develop herbicide tolerant varieties

Practical

Adjuvants and their effect on spray droplets, chemical entry and transport.
Determination of physiological and biochemical processes like photosynthesis, respiration, cell division, Protein & fatty acid synthesis, membrane permeability as affected by herbicides. Quantification of pigment levels in leaves, specific enzyme

activities affected by herbicides. Demonstration of translocating type of herbicides by radio labeling studies.

Suggested Readings

Devine MD, Duke SO & Fedtake C. 1993. *Physiology of Herbicide Action*. Prentice Hall.

Monaco TJ, Weller SC & Ashton FM. 2002. *Weed Science - Principles and Practices*. Wiley.com Publ.

8.PP 608 SEED PHYSIOLOGY 2+1

Objective

To appraise students regarding seed germination, dormancy and physiological processes involved in regulation of seed development

Theory

UNIT I

Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development.

UNIT II

Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.

UNIT III

Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development.

UNIT IV

Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds and their biosynthesis.

UNIT V

Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds, Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis.

UNIT VI

Control processes in mobilization of stored resources, Role of embryonic axes, Gibberllin and a-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins.

UNIT VII

Seed viability, Physiology of and means to prolong seed viability, Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it, Seed dormancy, types and regulation, Means to overcome seed dormancy.

Practical

Determination of seed storage proteins, Sink drawing ability of ovules, empty ovule technique, Alpha-amylase activity in germinating seeds, Role of GA in inducing amylase activity, Role of embryo in GA induced aamylase activity, Protease and lipase activity in germinating seeds, Seed viability test and accelerated ageing test. Seed hardening/osmotic priming of seeds, Seed respiration rates, Seed viability losses through membrane leakage studies.

Suggested Readings

Bewley JD & Black M. 1985. *Seed Physiology of Development and Germination*. Plenum Publ.
Copeland LO & McDonald MB**.** *Principles of Seed Sciences and Technology*. Burgers Publ. Co.
Srivastav L M. Plant Growth and Development - Hormones and Environment, Academic Press.

Journal/Books to be purchased in College Library for student's reference

1. List of Journals

- American Journal of Botany
- Annual Review of Plant Physiology and Plant Molecular Biology
- Botanical Review
- Environmental and Experimental Botany
- Indian Journal of Plant Physiology
- International Journal of Botany
- Journal of Experimental Botany
- Journal of Plant Nutrition
- New Physiologist
- Physiologia Plantarum
- Physiology and Molecular Biology of Plants
- Plant and Cell Physiology
- Plant Physiology and Biochemistry
- Plant Science (India)

II. List of Books

1. Kabita Datta 2007. *Plant Physiology*. Mittal Publ.
2. Srivastava L.M. 2002. *Plant Growth and Development: Hormones and Environment.* Academic Press.
3. Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.
4.Hunt R. *Plant Growth Curve - The Fundamental Approach to Plant Growth Analysis*. Edward Arnold.
5.John H, Thornley M & Johnson IR. *Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology*. Blackburn Press.
6.Vos J, Marcelis LFM, Visser PHBD, Struik PC & Evers JB. (Eds.). 2007.*Functional-Structural Plant Modelling in Crop Production.* Vol. XXII. Springer.
7.Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition*. CRC
8.Epstein E. 2007. *Mineral Nutrition of Plants*. John Wiley & Sons.
9.Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press.
10.Reddy KR & Hodges HF. 2000. *Climate Change and Global Crop Productivity*. CABI.

XI PLANT BIOTECHNOLOGY

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
MBB 501**	PRINCIPLES OF BIOTECHNOLOGY	2+1
MBB 502**	FUNDAMENTALS OF MOLECULAR BIOLOGY	3+0
MBB 503**	MOLECULAR CELL BIOLOGY	2+0
MBB 504	PLANT TISSUE CULTURE AND ITS APPLICATIONS	1+1
MBB 505**	TECHNIQUES IN MOLECULAR BIOLOGY I	0+3
MBB 506	MICROBIAL/ INDUSTRIAL BIOTECHNOLOGY	2+1
MBB 507	MOLECULAR BREEDING	2+0
MBB 508	GENOMICS & PROTEOMICS	2+0
MBB 509	TECHNIQUES IN MOLECULAR BIOLOGY II	0+3
MBB 510*	BIOSAFETY, IPR AND BIOETHICS	2+0
MBB 511*	ANIMAL BIOTECHNOLOGY	3+0
MBB 512*	IMMUNOLOGY AND MOLECULAR DIAGNOSTICS	2+1
MBB 513*	NANO-BIOTECHNOLOGY	3+0
MBB 514*	PLANT GENETIC ENGINEERING	1+1
MBB 515	INTRODUCTION TO BIOINFORMATICS	2+1
MBB 516	ENVIRONMENTAL BIOTECHNOLOGY	3+0
MBB 591	MASTER'S SEMINAR	0+1
MBB 599	MASTER'S RESEARCH	20
MBB 601	ADVANCES IN PLANT MOLECULAR BIOLOGY	3+0
MBB 602	ADVANCES IN GENETIC ENGINEERING	3+0
MBB 603	ADVANCES IN MICROBIAL BIOTECHNOLOGY	3+0
MBB 604	ADVANCES IN CROP BIOTECHNOLOGY	3+0
MBB 605	ADVANCES IN FUNCTIONAL GENOMICS AND PROTEOMICS	2+0
MBB 606	COMMERCIAL PLANT TISSUE CULTURE	2+0
MBB 607	ADVANCES IN ANIMAL BIOTECHNOLOGY	2+0
MBB 608	GENOMICS AND BIOINFORMATICS IN HORTICULTURE	2+1
MBB 609	ADVANCES IN BIOCHEMISTRY AND BIOTECHNOLOGY OF FLOWERS	2+1
MBB 610	APPLICATION OF BIOTECHNOLOGY IN FOODS AND NUTRITION	1+1
MBB 691	DOCTORAL SEMINAR I	0+1
MBB 692	DOCTORAL SEMINAR II	0+1
MBB 699	DOCTORAL RESEARCH	45

*May be taken as minor/supporting courses; **Compulsory for M.Sc. Programme

1.MBB 501 PRINCIPLES OF BIOTECHNOLOGY 2+1

Objective

To familiarize the students with the fundamental principles of Biotechnology, various developments in Biotechnology and its potential applications.

Theory

UNIT I

History, scope and importance; DNA structure, function and metabolism.

UNIT II

DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; Gene libraries; PCR amplification; Plant and animal cell and tissue culture techniques and their applications.

UNIT III

Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genetic engineering and transgenics; Genomics, transcriptomics and proteomics.

UNIT IV

General application of biotechnology in Agriculture, Medicine, Animal husbandry, Environmental remediation, Energy production and Forensics; Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Practical

i. Isolation of genomic and plasmid DNA
ii. Gel electrophoresis techniques
iii. Restriction enzyme digestion, ligation, transformation and screening of transformants
iv. PCR and molecular marker analysis
v. Plant tissue culture: media preparation, cell and explant culture, regeneration and transformation.

Suggested Readings

Becker JM, Coldwell GA & Zachgo EA. 2007. *Biotechnology – a Laboratory Course*. Academic Press.

Brown CM, Campbell I & Priest FG. 2005. *Introduction to Biotechnology*.Panima Pub.

Brown TA. *Gene Cloning and DNA Analysis*. 5th Ed. Blackwell Publishing.

Dale JW & von Schantz M. 2002. *From Genes to Genomes: Concepts and Applications of DNA Technology*. John Wiley & Sons.

Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publications.

Sambrook J, Fritsch T & Maniatis T. 2001. *Molecular Cloning - aLaboratory Manual*. 2nd Ed. Cold Spring Harbour Laboratory Press.

Singh BD. 2007. *Biotechnology Expanding Horiozon*. Kalyani Publishers.

2. MBB 502 FUNDAMENTALS OF MOLECULAR BIOLOGY 3+0

Objective

To familiarize the students with the basic cellular processes at molecular level.

Theory

UNIT I

Historical developments of molecular biology; Nucleic acids as genetic material; Chemistry, structure and properties of DNA and RNA.

UNIT II
Genome organization in prokaryotes and eukaryotes; Chromatin structure and function; DNA replication; DNA polymerases, topoisomerases, DNA ligase, etc; Molecular basis of mutations; DNA repair mechanisms.
UNIT III
Transcription process; RNA processing; Reverse transcriptase; RNA editing; Ribosomes structure and function; Organization of ribosomal proteins and RNA genes; Genetic code; Aminoacyl tRNA synthases.
UNIT IV
Translation and post-translational modifications; Operon concept; Attenuation of *trp* operon; important features of gene regulation in eukaryotes.

Suggested Readings

Lewin B. 2008. *Gene IX*. Peterson Publications/ Panima.
Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett Publishers.
Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. W.H. Freeman & Co.
Primrose SB. 2001. *Molecular Biotechnology*. Panima.
Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008.
Molecular Biology of the Gene. 6th Ed. Pearson Education International.

3. MBB 503 MOLECULAR CELL BIOLOGY 2+0

Objective
To familiarize the students with the cell biology at molecular level.

Theory
UNIT I
General structure and constituents of cell; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, structure and composition of biomembranes, cell surface related functions.
UNIT II
Structure and function of major organelles: Nucleus, Chloroplasts, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles, etc.
UNIT III
Organellar genomes and their manipulation; Ribosomes in relation to cell growth and division; Cyto-skeletal elements.
UNIT IV
Cell division and regulation of cell cycle; Membrane transport; Transport of water, ion and biomolecules; Signal transduction mechanisms; Protein targeting.

Suggested Readings
Gupta PK. 2003. *Cell and Molecular Biology*. 2nd Ed. Rastogi Publ.
Lodish H. 2003. *Molecular Cell Biology*. 5th Ed. W.H. Freeman & Co.
Primrose SB. 2001. *Molecular Biotechnology*. Panima.

4.MBB 504 PLANT TISSUE CULTURE AND ITS APPLICATIONS 1+1

Objective
To familiarize the students and provide hands on training on various techniques of plant tissue culture and its applications.

Theory

UNIT I
History of plant cell and tissue culture; Culture media; Various types of culture; callus, suspension, nurse, root, meristem, etc.; *In vitro*differentiation: organogenesis and somatic embryogenesis; Plant growth regulators: mode of action, effects on *in vitro* culture and regeneration; Molecular basis of plant organ differentiation.
UNIT II
Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* mutagenesis; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds.
UNIT III
Embryo rescue and wide hybridization; Protoplast culture and regeneration; Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids, etc.
UNIT IV
Applications of plant tissue culture; commercialized techniques; tissue culture based industries; cost benefit analysis

Practical

i. Laboratory set-up.
ii. Preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration.
iii. Anther and pollen culture.
iv. Embryo rescue.
v. Suspension cultures and production of secondary metabolites.
vi. Protoplast isolation, culture and fusion.
vii. Meristem culture
viii. Low cost techniques
ix. Commercial ventures

Suggested Readings

Bhojwani SS. 1983. *Plant Tissue Culture: Theory and Practice*. Elsevier.
Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.
Dixon RA. 2003. *Plant Cell Culture*. IRL Press.
George EF, Hall MA & De Klerk GJ. 2008. *Plant Propagation by TissueCulture*. Agritech Publ.
Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publ.
Herman EB. 2005-08. *Media and Techniques for Growth, Regeneration and Storage*. Agritech Publ.
Pena L. 2004. *Transgenic Plants: Methods and Protocols*. Humana Press.
Pierik RLM. 1997. *In vitro Culture of Higher Plants*. Kluwer.
Singh BD. 2007. *Biotechnology: Expanding Horiozon.* Kalyani.

5.MBB 505 TECHNIQUES IN MOLECULAR BIOLOGY I 0+3

Objective
To provide hands on training on basic molecular biology techniques.

Practical
UNIT I
Good lab practices; Biochemical techniques: Preparation of buffers and reagents, Principle of centrifugation, Chromatographic techniques (TLC,Gel Filtration Chromatography, Ion exchange Chromatography, AffinityChromatography).

UNIT II

Gel electrophoresis- agarose and PAGE (nucleic acids and proteins); Growth of bacterial culture and preparation of growth curve; Isolation of plasmid DNA from bacteria; Growth of lambda phage and isolation of phage DNA; Restriction digestion of plasmid and phage DNA; Isolation of high molecular weight DNA and analysis.

UNIT III

Gene cloning – Recombinant DNA construction, transformation and selection of transformants; PCR and optimization of factors affecting PCR.

UNIT IV

Dot blot analysis; Southern hybridization; Northern hybridization; Western blotting and ELISA; Radiation safety and non-radio isotopic procedure.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA &
Struhl K. 2002. *Short Protocols in Molecular Biology*. John Wiley.

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: aLaboratory Manual*. Cold Spring Harbour Laboratory Press.

6.MBB 506 MICROBIAL/ INDUSTRIAL BIOTECHNOLOGY 2+1

Objective

To familiarize about the various microbial processes/systems/activities,which have been used for the development of industrially important products/processes.

Theory

UNIT I

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

UNIT II

Primary metabolism products, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non ribosomal peptide antibiotics; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

UNIT III

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bioaugmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.

UNIT IV

Industrial biotechnology for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bioremediation of soil; Production of eco-friendly agricultural chemicals, biopesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc.

Practical

i. Isolation of industrially important microorganisms, their maintenance and improvement.

ii. Production of industrial compounds such as alcohol, beer, citric acid,lactic acid and their recovery.

iii. Study of bio-reactors and their operations.

iv. Production of biofertilizers.

v. Experiments on microbial fermentation process, harvesting purification and recovery of end products.
vi. Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation.
vii. Determination mass transfer co-efficients.

Suggested Readings

Huffnagle GB & Wernick S. 2007. *The Probiotics Revolution: The Definitive Guide to Safe, Natural Health*. Bantam Books.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Primrose SB. 2001. *Molecular Biotechnology*. Panima.

7. MBB 507 MOLECULAR BREEDING 2+0

Objective

To familiarize the students about the use of molecular biology tools in plant breeding.

Theory

UNIT I

Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Aspects of molecular breeding.

UNIT II

Development of sequence based molecular markers - SSRs and SNPs; Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits.

UNIT III

QTL mapping using structured populations; AB-QTL analysis; Association mapping of QTL; Fine mapping of genes/QTL; Map based gene/QTL isolation and development of gene based markers; Allele mining by TILLING and Eco-TILLING; Use of markers in plant breeding.

UNIT IV

Marker assisted selection (MAS) in backcross and heterosis breeding; Transgenic breeding; Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples.

Suggested Readings

Chittaranjan K. 2006-07. *Genome Mapping and Molecular Breeding in Plants.* Vols. I-VII. Springer.
Newbury HJ. 2003. *Plant Molecular Breeding*. Blackwell Publ.
Weising K, Nybom H, Wolff K & Kahl G. 2005. *DNA Fingerprinting in Plants: Principles, Methods and Applications*. Taylor & Francis.

8. MBB 508 GENOMICS AND PROTEOMICS 2+0

Objective

To familiarize the students with recent tools used for genome analysis and their applications.

Theory

UNIT I

Structural genomics: Classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing,sequence assembly and annotation; Comparative genomics, etc.

UNIT II

Functional genomics: DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Metabolomics and ionomics for elucidating metabolic pathways, etc.

UNIT III

Proteomics - Protein structure, function and purification; Introduction to basic proteomics technology; Bio-informatics in proteomics; Proteomeanalysis, etc.

UNIT IV

Applications of genomics and proteomics in agriculture, human health and industry.

Suggested Readings

Azuaje F & Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*. John Wiley & Sons.

Brown TA. 2007. *Genome III*. Garland Science Publ.

Campbell AM & Heyer L. 2004. *Discovery Genomics, Proteomics and Bioinformatics*. Pearson Education.

Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.

Jollès P & Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*. Birkhäuser.

Kamp RM. 2004. *Methods in Proteome and Protein Analysis*. Springer.

Primrose SB & Twyman RM. 2007. *Principles of Genome Analysis and Genomics*. Blackwell.

Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II. Wiley CVH.

9.MBB 509 TECHNIQUES IN MOLECULAR BIOLOGY II 0+3

Objective

To provide hands on training on various molecular techniques used in molecular breeding and genomics.

Practical

UNIT I

Construction of gene libraries; Synthesis and cloning of cDNA and RTPCRanalysis; Real time PCR and interpretation of data.

UNIT II

Molecular markers (RAPD, SSR, AFLP etc) and their analysis; Case study of SSR markers (linkage map, QTL analysis etc); SNP identification and analysis; Microarray studies and use of relevant software.

UNIT III

Proteomics (2D gels, mass spectrometry, etc.); RNAi (right from designing of construct to the phenotyping of the plant); Yeast 1 and 2-hybrid interaction.

UNIT IV

Generation and screening of mutants; Transposon mediated mutagenesis.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. Wiley.

Caldwell G, Williams SN & Caldwell K. 2006. *Integrated Genomics: A Discovery-Based Laboratory Course*. John Wiley.

Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbour Laboratory Press.

10.MBB 510 BIOSAFETY, IPR AND BIOETHICS 2+0

Objective

To discuss about various aspects of biosafety regulations, IPR and bioethic concerns arising from the commercialization of biotech products.

Theory

UNIT I

Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm; Risk management issues - containment.

UNIT II

General principles for the laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance, etc; Impact on environment: gene flow in natural and artificial ecologies; Sources of gene escape, tolerance of target organisms, creation of superweeds/superviruses, etc.

UNIT III

Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and nonradio isotopic procedure; Benefits of transgenics to human health, society and the environment.

UNIT IV

The WTO and other international agreements; Intellectual properties, copyrights, trademarks, trade secrets, patents, geographical indications, etc; Protection of plant variety and farmers right act; Indian patent act and amendments, patent filing; Convention on biological diversity; Implications of intellectual property rights on the commercialization of biotechnology products.

Suggested Readings

Singh BD. 2007. *Biotechnology: Expanding Horizon*. Kalyani.
http://patentoffice.nic.in
www.wipo.org
www.dbtindia.nic.in
www.dbtbiosafety.nic.in

11.MBB 511 ANIMAL BIOTECHNOLOGY 3+0

Objective

Intended to provide an overview and current developments in different areas of animal biotechnology.

Theory

UNIT I

Structure of animal cell; History of animal cell culture; Cell culture media and reagents, culture of mammalian cells, tissues and organs, primary culture, secondary culture, continuous cell lines, suspension cultures, somatic cell cloning and hybridization, transfection and transformation of cells, commercial scale production of animal cells, application of animal cell culture for *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

UNIT II

Introduction to immune system, cellular and hormonal immune response, history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production,

hybridoma technology, phage display technology for production of antibodies, antigen-antibody based diagnostic assays including radioimmunoassays and enzyme immunoassays, immunoblotting, nucleic acid based diagnostic methods, commercial scale production of diagnostic antigens and antisera, animal disease diagnostic kits, probiotics.

UNIT III

Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, *in vitro* fertilization, culture of embryos, cryopreservation of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning basic concept, cloning from-embryonic cells and adult cells, cloning of different animals, cloning for conservation for conservation endangered species, ethical, social and moral issues related to cloning, *in situ* and *ex situ* preservation of germplasm, *in utero* testing of foetus for genetic defects, pregnancy diagnostic kits, anti-fertility animal vaccines, gene knock out technology and animal models for human genetic disorders.

UNIT IV

Introduction to different breeds of cattle, buffalo, sheep, goats, pigs, camels, horses, canines and poultry, genetic characterization of livestock breeds, marker assisted breeding of livestock, introduction to animal genomics, different methods for characterization of animal genomes, SNP,STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Transgenic animal production and application in expression of therapeutic proteins. Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection food/feed adulteration with animal protein, identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts confiscated by anti-poaching
agencies.

Suggested Readings

Gordon I. 2005. *Reproductive Techniques in Farm Animals*. CABI.
Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby Immunology*. WH Freeman.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. *NewGeneration Vaccines*. 3rd Ed. Informa Healthcare.
Lincoln PJ & Thomson J. 1998. *Forensic DNA Profiling Protocols*.Humana Press.
Portner R. 2007. *Animal Cell Biotechnology*. Humana Press.
Spinger TA. 1985. *Hybridoma Technology in Biosciences and Medicine*.Plenum Press.
Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

12.MBB 512 IMMUNOLOGY AND MOLECULAR DIAGNOSTICS 2+1

Objective

To discuss the application of various immunological and molecular diagnostic tools.

Theory

UNIT I

History and scope of immunology; Components of immune system: organs,tissues and cells, Immunoglobulin chemistry, structure and functions;Molecular organization of immunoglobulins and classes of antibodies.

UNIT II

Antibody diversity; antigens, haptens, antigens- antibody interactions;immuno-regulation and tolerance; Allergies and hypersensitive response; Immunodeficiency; Vaccines; Immunological techniques.

UNIT III

Immunological application in plant science, monoclonal antibodies and their uses, molecular diagnostics. Introduction to the basic principles of molecular technology and techniques used in pathogen detection, Principles of ELISA and its applications in viral detection.

UNIT IV

Basics and procedures of PCR, Real time PCR, PCR based and hybridization based methods of detection, microarrays based detection,multiplexing etc, detection of soil borne and seed born infections,transgene detection in seed, planting material and processed food,molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical

i. Preparation of buffers and reagents.

ii. Immunoblotting, immunoelectrophoresis and fluorescent antibody test.

iii. Enzyme immunoassays including ELISA western blotting.

iv. Extraction and identification of DNA/RNA of pathogenic organisms.

v. Restriction hybridoma technique and production of monoclonal antibodies.

vi. Immunogenic proteins, expression and immunogenecity studies, purification of immunogenic protein and immunization of laboratory animals.

Suggested Readings

Bloom BR & Lambert P-H. 2002. *The Vaccine Book.* Academic Press.

Elles R & Mountford R. 2004. *Molecular Diagnosis of Genetic Disease*.Humana Press.

Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby's Immunology*. WH Freeman.

Levine MM, Kaper JB, Rappuoli R, Liu MA & Good MF. 2004. *NewGeneration Vaccines*. 3rd Ed. Informa Healthcare.

Lowrie DB & Whalen R. 2000. *DNA Vaccines*. Humana Press.

Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology.* Elsevier.

Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics*. Horizon Bioscience.

Robinson A & Cranage MP. 2003. *Vaccine Protocols*. 2nd Ed. Humana Press.

Spinger TA, 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

13. MBB 513 NANO-BIOTECHNOLOGY 3+0

Objective

Understanding the molecular techniques involved in structure and functions of nano-biomolecules in cells such as DNA, RNA and proteins.

Theory

UNIT I

Introduction to Biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules: scattering techniques, micromanipulation techniques, drug delivery applications etc.

UNIT II

Cellular engineering: signal transduction in biological systems, feedback control signaling pathways, cell-cell interactions etc. Effects of physical,chemical and electrical stimuli on cell function and gene regulation.

UNIT III

Chemical, physical and biological properties of biomaterials and bioresponse: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems,

UNIT IV

Preparation and characterization of nanoparticles; Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

Suggested Readings

Nalwa HS. 2005. *Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology*. American Scientific Publ.

Niemeyer CM & Mirkin CA. 2005. *Nanobiotechnology*. Wiley Interscience.

14. MBB 514 PLANT GENETIC ENGINEERING (1+1)

Theory

Genetic Engineering – Principles and methods – DNA cloning strategies. Modification of nuclear and organelle genome in plants-Methods of genetic transformation-direct and indirect methods-types of vectors-Ti, Ri and helper plasmids-mechanism of gene transfer-modification of vectors-screening of recombinants-selectable markers-reporter genes-molecular techniques for confirmation of transformation. Direct methods-electroporation-particle gun-biolistics-microinjection-chemical methods-biosafety guidelines, biosafety and IPR-issues and concerns, applications of genetic engineering for crop improvement-recent advances.

Practical

Culturing of *Agrobacterium* Screening for antibiotic sensitivity-isolation of Ti plasmid-gene cloning & modification of vectors-triparental mating-transformation of plants-screening of recombinants-transient expression of GUS, GFP etc.-regeneration of transformed tissue-Confirmation of transformation through PCR nucleic acid hybridization.

Suggested readings

Primrose, S.B. 1987. Modern Biotechnology. Blackwell Scientific Co., USA.

Primorse, S.B. & Twyman, R.M., 2006. Principles of gene manipulation and Genomics Blackwell Publishing, USA.

Singh, R.P & Jaiwal, P.K., 2003. Plant Genetic Engineering Vol. 1 – 5 SCI Tech Publishing, USA

Brown, T.A. 2006. Gene cloning and DNA analysis. Blackwell Publishing, USA

15.MBB 515 INTRODUCTION TO BIOINFORMATICS 2+1

Objective

To impart an introductory knowledge about the subject of bioinformatics to the students studying any discipline of science.

Theory

UNIT I

Introduction, biological databases – primary, secondary and structural, Protein and Gene Information Resources – PIR, SWISSPROT, PDB, genebank, DDBJ. Specialized genomic resources.

UNIT II

DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques, database searching, multiple sequence alignment.

UNIT III

Secondary database searching, building search protocol, computer aideddrug design – basic principles, docking, QSAR.

UNIT IV

Analysis packages – commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical

i. Usage of NCBI resources
ii. Retrival of sequence/structure from databases
iii. Visualization of structures
iv. Docking of ligand receptors
v. BLAST exercises.

Suggested Readings

Attwood TK & Parry-Smith DJ. 2003. *Introduction to Bioinformatics*. Pearson Education.

Rastogi SC, Mendiratta N & Rastogi P. 2004. *Bioinformatics: Concepts,Skills and Applications*. CBS.

16.MBB 516 ENVIRONMENTAL BIOTECHNOLOGY 3+0

Objective

To apprise the students about the role of biotechnology in environment management for sustainable eco-system and human welfare.

Theory

UNIT I

Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes; need for water and natural resource management.

UNIT II

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents etc; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes: digestion, filteration, etc.

UNIT III

Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas;microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers;composting; vermiculture, etc.

UNIT IV

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

Suggested Readings

Evans GM & Furlong JC. 2002. *Environmental Biotechnology: Theory and Application*. Wiley International.

Jordening H-J & Winter J. 2006. *Environmental Biotechnology: Conceptsand Applications*. Wiley-VCH Verlag.

Ph.D.COURSES

1. MBB 601 ADVANCES IN PLANT MOLECULAR BIOLOGY 3+0

Objective

To discuss the specialized topics and recent advances in the field of plant molecular biology.

Theory

UNIT I

Arabidopsis in molecular biology, Forward and Reverse Genetic Approaches, Transcriptional and post-transcriptional regulation of geneexpression, isolation of promoters and other regulatory elements.

UNIT II

RNA interference, Transcriptional gene silencing, Transcript and protein analysis, use of transcript profiling to study biological systems.

UNIT III

Hormone regulatory pathways: Ethylene, Cytokinin, Auxin and ABA, SA and JA; ABC Model of Floral Development, Molecular basis of self incompatibility, Regulation of flowering: photoperiod, vernalization, circadian rhythms.

UNIT IV

Molecular biology of abiotic stress responses: Cold, high temperature, submergence, salinity and drought; Molecular Biology of plant-pathogen interactions, molecular biology of *Agrobacterium* Infection, Molecular biology of *Rhizobium* infection (molecular mechanisms in symbiosis), Programmed cell death in development and defense.

Suggested Readings

Buchanan B, Gruissen W & Jones R. 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, USA.

Lewin B. 2008. *Gene IX*. Peterson Publications/ Panima.

Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett Publ.

Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. WH Freeman & Co.

Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene.* 6th Ed. Pearson Education.

2.MBB 602 ADVANCES IN GENETIC ENGINEERING 3+0

Objective

To discuss the specialized topics and advances in field of genetic engineering and their application in plant improvement.

Theory

UNIT I

General overview of transgenic plants; Case studies: Genetic engineering of herbicide resistance, Transgenic plants resistant to insects/pests, Genetic engineering of abiotic stress tolerance, Engineering food crops for quality, Genetically engineered pollination control, Induction of male sterility in plants.

UNIT II

Molecular farming of plants for applications in veterinary and human medicine systems: Boosting heterologous protein production in transgenics, Rapid production of specific vaccines, High-yield production of therapeutic proteins in chloroplasts.

UNIT III

Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement; Gene stacking; Pathway engineering; Marker-free transgenic development strategies; High throughput phenotyping of transgenic plants.

UNIT IV

Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

Suggested Readings

Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.
Specific journals and published references.

3.MBB 603 ADVANCES IN MICROBIAL BIOTECHNOLOGY 3+0

Objective

To discuss specialized topics about industrially important microorganisms.

Theory

UNIT I

Fermentative metabolism and development of bioprocessing technology, processing and production of recombinant products; isolation, preservation and improvement of industrially important microorganisms.

UNIT II

Immobilization of enzymes and cells; Batch, plug flow and chemostate cultures; Computer simulations; Fed-batch and mixed cultures; Scale-up principles; Down stream processing etc.

UNIT III

Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioreactors; Bioprocess engineering; Production of non-microbial origin products by genetically engineered microorganisms.

UNIT IV

Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Factors affecting delignification; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins; Single cell protein, Bioinsecticides; Biofertilizers; Recent advances in microbial biotechnology.

Suggested Readings

Specific journals and published references.

4. MBB 604 ADVANCES IN CROP BIOTECHNOLOGY 3+0

Objective

To discuss specialized topics on the application of molecular tools in breeding of specific crops.

Theory

UNIT I

Conventional versus non-conventional methods for crop improvement;Present status and recent developments on available molecular marker,transformation and genomic tools for crop improvement.

UNIT II

Genetic engineering for resistance against abiotic (drought, salinity,flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc); edible vaccines, etc.

UNIT III

Molecular breeding: constructing molecular maps; integrating genetic, physical and molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/traits; selected examples on marker assisted selection of qualitative and quantitative traits.

UNIT IV

Discussion on application of molecular, transformation and genomic tools for the genetic enhancement in some major field crops such as rice, wheat, cotton, maize, soybean, oilseeds, sugarcane etc.

Suggested Readings

Specific journals and published references.

5.MBB 605 ADVANCES IN FUNCTIONAL GENOMICS AND PROTEOMICS 2+0

Objective

To discuss recent advances and applications of functional genomics and proteomics in agriculture, medicine and industry.

Theory

UNIT I

Genome sequencing and functional genomics; Human, animal, plant, bacterial and yeast genome projects; genome annotation; *ab initio* gene discovery; functional annotation and gene family clusters; etc.

UNIT II

Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ T-DNA insertion lines; homologous recombination; microarray profiling; SAGE; SNPs/variation; yeast-two hybrid screening; gene expression and transcript profiling; EST contigs; EcoTILLING; allele/gene mining; synteny and comparative genomics; Genome evolution, speciation and domestication etc.

UNIT II

Proteomics: protein annotation; protein separation and 2D PAGE; mass spectroscopy; protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading, software and data analysis/ management, etc.

UNIT IV

Discussion on selected papers on functional genomics, proteomics, integrative genomics etc.

Suggested Readings

Specific journals and published references.

6. MBB 606 COMMERCIAL PLANT TISSUE CULTURE 2+0

Objective

To discuss the commercial applications of plant tissue culture in agriculture, medicine and industry.

Theory

UNIT I

Micropropagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

UNIT II

Production of useful compounds via biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry.

UNIT III

Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethic issues; management and commercialization.

UNIT IV

Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

Suggested Readings

Specific journals and published references.

7. MBB 607 ADVANCES IN ANIMAL BIOTECHNOLOGY 2+0

Objective

Intended to provide cutting edge knowledge on advances in different areasof animal biotechnology.

Theory

UNIT I

Advances in animal cell culture technology, suspension culture technology, advances in commercial scale productions of mammalian cells.

UNIT II

Advances in cell cloning and cell hybridization, advances in monoclonal antibody production technology, Advances in diagnostic technology, Computational vaccinology, reverse genetics based vaccines.

UNIT III

Advances in embryo manipulation, knock out and knock in technology, advances in animal cloning technology, stem cell technology, Advances in development of animal models for human diseases using transgenic animal technology.

UNIT IV

Advances in genetic basis for animal disease resistance, Molecular methods for animal forensics, Advances in animal genomics, proteomics.

Suggested Readings

Selected articles from journals.

8. MBB 608 GENOMICS AND BIOINFORMATICS IN HORTICULTURE 2+1

Objective

Studies on the fundamentals and application of genomics and bioinformatics in horticulture.

Theory

UNIT I

Primer on bioinformatics and computational genomics, database fundamentals – biological databases, horticultural genome and protein databases, functional genomics.

UNIT II

Dynamic Programming Sequence Alignment, BLAST search engine, FASTA search engine, Microarrays- Microarray Clustering and Classification, Terminologies and Ontologies - EcoCYC knowledge base of E. Coli metabolism - Description of UMLS Semantic Network.

UNIT III

Multiple Sequence Alignment, MSA algorithm descriptions, ClustalW, 1D Motifs, Algorithms and Databases, methods for sequence weighting, BLOCKS database, Making BLOCK motifs, PROSITE database, 3D structure alignment, SCOP, DALI, LOCK, MUSTA algorithm for geometric hashing and multiple alignmen t.

UNIT IV

Hidden Markov models , Molecular energetics and dynamics , Protein structure prediction, Genetic networks - Modeling and Simulation of Genetic Regulatory Systems- KEGG database of genes and gene pathways/networks - EcoCYC database of metabolic pathways in E. Coli - EGF-signal pathway modeling, Gene finding algorithms – Genome Annotation Assessment Project for Arabidopsis, Comparative genomics algorithms, Genome Alignment.

UNIT V

3D structure computations, NMR, Xtallography, NMR Structure Determination , X-ray Crystallography Structure Determination, Distance Geometry Description, RNA secondary structure, Molecular Modeling and Drug discovery programs.

UNIT VI

Phylogenetic algorithms - Treebase database of phylogenetic information for plants mostly, Tree of Life Page, Samples from the Tree of Life, Ribosomal Database Project, Natural Language Processing , Proteomics, 3D Motifs, Applications and Integration with Horticulture, Final Thoughts.

Practical

Computers, Operating systems and Programming languages, Internet Resources, Horticultural Genome and Protein Databases, BLAST/RNA Structure, Sequence Alignment, Microarray Data Analysis, Ontology, MSA, HMMs, Identification of Functional Sites in Structures, Protein Structure Prediction - Phylogenetics - Gene Finding - Molecular Modeling and Drug Discovery Software – Assignments.

Suggested Readings

Attwood TK & Parry Smith DJ. 2006. *Introduction to Bioinformatics*. Pearson Edu.

Baxevanis AD. 2005. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. 3rd Ed. Wiley.

Bourne PE & Weissig H. (Eds.). 2004. *Structural Bioinformatics*. John Wiley & Sons.

Durbin R, Eddy SR, Krogh A & Mitchison G. 1999. *Biological Sequence Analysis: Probabilistic Model of Proteins and Nucleic Acids*.Cambridge Univ. Press.

Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. New India Publ. Agency.

Kohane IS, Kho A & Butte AJ. 2002. *Microarrays for an Integrative Genomics*. M1T Press.

Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbour Laboratory Press.

9.MBB 609 ADVANCES IN BIOCHEMISTRY AND BIOTECHNOLOGY OF FLOWERS 2+1

Objective

Appraisal on the advances in biochemistry of flowers and application of biotechnology in flower crops.

Theory

UNIT I

Biochemistry of flowers: Principle involved in the formation of pigments –chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins.Chemistry and importance of secondary metabolites in rose, jasmine, marigold, tuberose, carnation, orchids, liliums and bougainvillea. Biochemistry and utilization commercial products (select items).

UNIT II

Recent trends- Extraction of biocolours and their value addition, uses in food and textile industries. Biochemistry of post harvest management of cut flowers.

UNIT III

Biotechnology – tools techniques and role in floriculture industry, physical factors and chemical factors influencing the growth and development of plant cell, tissue and organs, cytodifferentiation, organogenesis, somatic embryogenesis.

UNIT IV

In vitro lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, *in vitro* pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery.

UNIT V

Somoclonal variation and its applications – variability induction through *in vitro* mutation, development of cell suspension cultures, types and techniques, *in vitro* production of secondary metabolites, role of bioreactors in production of secondary metabolites, quantification and quality analysis of secondary metabolites using HPLC, *in vitro* conservation and cryo-preservation techniques.

UNIT VI

Gene cloning, genetic engineering: vectors and methods of transformation – electroporation, particle bombardment, *Agrobacterium* mediated, transgenic plants in flower crops, medicinal and aromatic crops, isolation of DNA, RNA, quantification, Polymerase Chain Reaction for amplification; AGE & PAGE techniques; identification of molecular markers.

UNIT VII

Construction of c- DNA library, DNA fingerprinting technique in economic flower crop varieties, molecular approaches to control ethylene response, improving shelf life, improving resistance for environmental stress, approaches to improve flower development, pigment production, secondary metabolite production, post harvest biotechnology of flowers, ornamental plants, achievements of bio-technology in flower crops.

Practical

Extraction of flower pigments – xanthophylls, carotenoids and anthocyanins. Plant nutrient stock- growth regulators- media preparation and sterilization- *In vitro* seed germination- callus culture and organ culture- Cell suspension culture – cell plating and regeneration- clonal propagation through Meristem culture, induction of multiple shoots- Anther- Pollen- Ovule and Embryo culture- Synthetic seed production, *in*

vitro mutation induction, *in vitro* rooting – hardening at primary and secondary nurseries, Project preparation for establishment of low, medium and high cost tissue culture laboratories, DNA isolation from economic flower crop varieties – Quantification and amplification, DNA and Protein profiling – molecular markers for economic flower crops, restriction enzymes, vectors for cloning and particle bombardment, DNA fingerprinting of flower crop varieties .

Suggested Readings

Chopra VL & Nasim. 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications.* Oxford & IBH.
Debnath M. 2005. *Tools and Techniques of Biotechnology*. Pointer Publ.
Dey PM & Harborne JB. 1997. *Plant Biochemistry*. 2nd Ed. Academic Press.
Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall.
Goodwin TW & Mercer EI. 2003. *Introduction to Plant Biochemistry*.CBS.
Gorden H & Rubsell S. 1960. *Hormones and Cell Culture*. AB Book Publ.
Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Methods in Tissue Culture and Gene Transfer*. Orient & Longman (Universal Press).
Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. (Eds.).
2007. Recent Trends in Horticultural Biotechnology. Vols. I, II. New India Publishing Agency.
Panopoulas NJ. (Ed.). 1981. *Genetic Engineering in Plant Sciences*. Praeger Publ.
Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S.
2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash.
Pierik RLM. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.
Prasad S. 1999. *Impact of Plant Biotechnology on Horticulture*. 2nd Ed.Agro Botanica.
Sharma R. 2000. *Plant Tissue Culture*. Campus Books International.Singh BD. 2001. *Biotechnology*. Kalyani.
Skoog Y & Miller CO. 1957. *Chemical Regulation of Growth andFormation in Plant Tissue Culture in vitro*. Symp. Soc. Exp. Biol.11: 118-131.
Vasil TK, Vasi M, While DNR & Bery HR. 1979. *Somatic Hybridizationand Genetic Manipulation in Plants*. *Plant Regulation and WorldAgriculture*. Planum Press.
Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V.www.amazon.com

10.MBB 610 APPLICATION OF BIOTECHNOLOGY IN FOODS AND NUTRITION 1+1

Objective

To acquaint the students with recent advances in role and application of biotechnology in Foods and Nutrition.

Theory

UNIT I

History, processes and products of biotechnology; applications of biotechnology in production of nutritious foods.

UNIT II

Role of biotechnology in ensymology and product development, fermentation process, fruit juice extraction, genetic improvement of food grade microorganisms.

UNIT III

Nutritional significance of food products developed by biotechnological techniques.

UNIT IV

Scientific, technological and resource constraints on biotechnology. Important factors affecting development of biotechnology.

Practical

Product development by biotechnological techniques.

Suggested Readings

Nestle, M. 2003. Safe Food: Bacteria, Biotechnology and Bioterrorism. University of California Press.

Rogers, P.L. and Fleet, G.H. 1989. Biotechnology and Food Industry. University of Minnesota.

List of Journals

- Advances in Botanical Research
- Advances in Enzyme Regulation
- Advances in Enzymology
- Advances in Genetics
- Agricultural and Biological Research
- Analytical Biochemistry
- Annals of Botany
- Archives of Biochemistry and Biophysics
- Archives of Microbiology
- Biochemical and Biophysical Research Communication
- Biochemical Genetics
- Biochemistry
- Biotechnology and Bioengineering
- Critical Reviews in Plant Sciences
- Crop Science
- EMBO Journal
- Euphytica
- Genetic and Plant Breeding
- Genome
- Indian Journal of Genetics and Plant Breeding
- Journal of Biotechnology
- Journal of Experimental Botany
- Journal of General Microbiology
- Journal of Heredity
- Journal of Plant Biochemistry and Biotechnology
- Journal of Plant Biology
- Molecular and Cellular Biochemistry
- Molecular Breeding
- Molecular Genetics and Genomics
- Nature
- Nature Biotechnology
- Plant Cell
- Plant Molecular Biology
- Plant Physiology
- Plant Physiology and Biochemistry
- Proceedings of The National Academy of Sciences (USA)
- Science
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Cell Biology
- Trends in Food Science and Technology
- Trends in Genetics

 Trends in Microbiology
 Trends in Plant Sciences

e-Resources

 National Center for Biotechnology Information
http://www.ncbi.nlm.nih.gov/
 The World Wide Web Virtual Library: Biotechnology.
31
http://www.cato.com/biotech/
 The Transgenic/Targeted Mutation Database (TBASE)
http://www.bis.med.jhmi.edu/Dan/tbase/tbase.html
 Primer on Molecular Genetics
http://www.bis.med.jhmi.edu/Dan/DOE/intro.html.
 Bioportal
http://bioportal.gc.ca/english/BioPortalHome.asp
 Access Excellence
http://www.gene.com/ae
 BioTech Biosources Database: Indiana University
http://biotech.chem.indiana.edu/
 Information Systems for Biotechnology
http://gophisb.biochem.vt.edu/
 All About The Human Genome Project (HGP)
http://www.genome.gov/
 Human Genome Project at the Sanger Institute
http://www.sanger.ac.uk/HGP/
 UCSC Genome Browser
http://genome.ucsc.edu/
 Gramene
www.gramene.org/
 The Institute for Genomic Research
www.tigr.org

Suggested Broad Topics for Master's and Doctoral Research

 Micropropagation of important crop plants, cash crops, ornamentals, forest and horticultural trees, medicinal and aromatic plants.
 Development of transgenics in field crops for resistance against biotic and abiotic stresses, and to improve the nutritional quality, etc.
 DNA fingerprinting of important plant species and germplasm.
 Development of molecular markers (SNP, SSR, transposable elements, etc) and their utilization for genetic diversity and phylogenetic analysis.
 Molecular mapping and marker-assisted selection for major-gene traits in crop species.
 Value-addition including biopesticides, biofertilizers, biofuels, biodegradable plastics, secondary metabolites, etc.
 Genome sequencing and functional analysis of genes of important organisms.
 Allele mining, proteomics, genomics and metabolic engineering for crop improvement.
 Immobilization of enzymes/microorganisms.
 Protein engineering.
 To develop crops with improved mineral (Fe, Zn, Vitamin A, etc) bioavailbility.
 Biodiversity and conservation of endangered plant species.
 Bioprocess engineering and down stream processing.

XII VEGETABLE SCIENCE

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
VSC 501*	PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS	2+1
VSC 502*	PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS	2+1
VSC 503*	BREEDING OF VEGETABLE CROPS	2+1
VSC 504*	GROWTH AND DEVELOPMENT OF VEGETABLE CROPS	2+1
VSC 505	SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS	2+1
VSC 506	SYSTEMATICS OF VEGETABLE CROPS	1+1
VSC 507	PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS	1+1
VSC 508	ORGANIC VEGETABLE PRODUCTION TECHNOLOGY	1+1
VSC 591	MASTER'S SEMINAR	1+0
VSC 599	MASTER'S RESEARCH	20
VSC 601**	ADVANCES IN VEGETABLE PRODUCTION	2+1
VSC 602**	ADVANCES IN BREEDING OF VEGETABLE CROPS	2+1
VSC 603**	PROTECTED CULTIVATION OF VEGETABLE CROPS	1+1
VSC 604**	BIOTECHNOLOGY OF VEGETABLE CROPS	2+1
VSC 605	SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE CROPS	1+1
VSC 606	ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS	2+1
VSC 691	DOCTORAL SEMINAR I	1+0
VSC 692	DOCTORAL SEMINAR II	1+0
VSC 699	DOCTORAL RESEARCH	45

Compulsory for Master's programme; **Compulsory for Doctoral programme

1.VSC 501 PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS 2+1

Objective

To educate production technology of cool season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:

UNIT I

Potato

UNIT II

Cole crops: cabbage, cauliflower, knoll kohl, sprouting broccoli, Brussels sprout

UNIT III

Root crops: carrot, radish, turnip and beetroot

UNIT IV

Bulb crops: onion and garlic

UNIT V

Peas and broad bean, green leafy cool season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial greenhouse/ polyhouse.

Suggested Readings

Bose TK & Som MG. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.

Bose TK, Som G & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.

Bose TK, Som MG & Kabir J. (Eds.). 1993. *Vegetable Crops*. Naya Prokash.

Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.

Chadha KL & Kalloo G. (Eds.). 1993-94. *Advances in Horticulture* Vols. V-X. Malhotra Publ. House.

Chadha KL. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.

Chauhan DVS. (Ed.). 1986. *Vegetable Production in India*. Ram Prasad & Sons.

Decoteau DR. 2000. *Vegetable Crops*. Prentice Hall.

Edmond JB, Musser AM & Andrews FS. 1951. *Fundamentals of Horticulture*. Blakiston Co.

Fageria MS, Choudhary BR & Dhaka RS. 2000. *Vegetable Crops: Production Technology*. Vol. II. Kalyani.

Gopalakrishanan TR. 2007. *Vegetable Crops*. New India Publ. Agency.

Hazra P & Som MG. (Eds.). 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.

Rana MK. 2008. *Olericulture in India*. Kalyani Publ.

Rana MK. 2008. *Scientific Cultivation of Vegetables*. Kalyani Publ.

Rubatzky VE & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.

Saini GS. 2001. *A Text Book of Oleri and Flori Culture*. Aman Publ. House.

Salunkhe DK & Kadam SS. (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.
Shanmugavelu KG. 1989. *Production Technology of Vegetable Crops*. Oxford & IBH.
Singh DK. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.
Singh SP. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.
Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
Thompson HC & Kelly WC. (Eds.). 1978. *Vegetable Crops*. Tata McGraw- Hill.

2.VSC 502 PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS 2+1

Objective

To teach production technology of warm season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of:

UNIT I

Tomato, eggplant, hot and sweet peppers

UNIT II

Okra, beans, cowpea and clusterbean

UNIT III

Cucurbitaceous crops

UNIT IV

Tapioca and sweet potato

UNIT V

Green leafy warm season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

Suggested Readings

Bose TK & Som MG. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.
Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.
Bose TK, Som MG & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.
Brown HD & Hutchison CS. *Vegetable Science*. JB Lippincott Co.
Chadha KL & Kalloo G. (Eds.). 1993-94. *Advances in Horticulture*. Vols. V-X. Malhotra Publ. House.
Chadha KL. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.
Chauhan DVS. (Ed.). 1986. *Vegetable Production in India*. Ram Prasad & Sons.
Decoteau DR. 2000. *Vegetable Crops*. Prentice Hall.
Edmond JB, Musser AM & Andrews FS. 1964. *Fundamentals of Horticulture*. Blakiston Co

Fageria MS, Choudhary BR & Dhaka RS. 2000. *Vegetable Crops: Production Technology*. Vol. II. Kalyani.
Gopalakrishanan TR. 2007. *Vegetable Crops*. New India Publ. Agency.
Hazra P & Som MG. (Eds.). 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.
Kalloo G & Singh K (Ed.). 2000. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals & Book Publ.House.
Nayer NM & More TA 1998. *Cucurbits*. Oxford & IBH Publ.
Palaniswamy & Peter KV. 2007. *Tuber Crops*. New India Publ. Agency.
Pandey AK & Mudranalay V. (Eds.). *Vegetable Production in India: Important Varieties and Development Techniques.*
Rana MK. 2008. *Olericulture in India*. Kalyani.
Rana MK. 2008. *Scientific Cultivation of Vegetables*. Kalyani.
Rubatzky VE & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.
Saini GS. 2001. *A Text Book of Oleri and Flori Culture*. Aman Publ. House.
Salunkhe DK & Kadam SS. (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.
Shanmugavelu KG. 1989. *Production Technology of Vegetable Crops*. Oxford & IBH.
Singh DK. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.
Singh NP, Bharadwaj AK, Kumar A & Singh KM. 2004. *Modern Technology on Vegetable Production*. International Book Distributing Co.
Singh SP. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.
Thamburaj S & Singh N. 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
Thompson HC & Kelly WC. (Eds.). 1978. *Vegetable Crops*. Tata Mc Graw Hill.

3.VSC 503 BREEDING OF VEGETABLE CROPS 2+1

Objective

To educate principles and practices adopted for breeding of vegetable crops.

Theory

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act.

UNIT I

Potato and tomato

UNIT II

Eggplant, hot pepper, sweet pepper and okra

UNIT III

Peas and beans, amaranth, chenopods and lettuce

UNIT IV

Gourds, melons, pumpkins and squashes

UNIT V

Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca

Practical

Selection of desirable plants from breeding population observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating

generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops in bulk. screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques. Visit to breeding blocks.

Suggested Readings

Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.
Basset MJ. (Ed.). 1986. *Breeding Vegetable Crops*. AVI Publ.
Dhillon BS, Tyagi RK, Saxena S. & Randhawa GJ. 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publ. House.
Fageria MS, Arya PS & Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani.
Gardner EJ. 1975. *Principles of Genetics*. John Wiley & Sons.
Hayes HK, Immer FR & Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.
Hayward MD, Bosemark NO & Romagosa I. (Eds.). 1993. *Plant Breeding- Principles and Prospects*. Chapman & Hall.
Kalloo G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.
Kalloo G. 1998. *Vegetable Breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.
Paroda RS & Kalloo G. (Eds.). 1995. *Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Regi*on. FAO.
Peter KV & Pradeepkumar T. 2008. *Genetics and Breeding of Vegetables.* Revised, ICAR.
Rai N & Rai M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publ. Agency.
Ram HH. 1998. *Vegetable Breeding: Principles and Practices*. Kalyani.
Simmonds NW. 1978. *Principles of Crop Improvement*. Longman.
Singh BD. 1983. *Plant Breeding*. Kalyani.
Singh PK, Dasgupta SK & Tripathi SK. 2004. *Hybrid Vegetable Development*. International Book Distributing Co.
Swarup V. 1976. *Breeding Procedure for Cross-pollinated Vegetable Crops*. ICAR.

4.VSC 504 GROWTH AND DEVELOPMENT OF VEGETABLE CROPS 2+1

Objective

To teach the physiology of growth and development of vegetable crops.

Theory

UNIT I

Cellular structures and their functions; definition of growth and development, growth analysis and its importance in vegetable production.

UNIT II

Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic hormones, plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production.

UNIT III

Role of light, temperature and photoperiod on growth, development of underground parts, flowering and sex expression in vegetable crops; apical dominance.

UNIT IV

Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.

UNIT V

Plant growth regulators in relation to vegetable production; morphogenesis and tissue culture techniques in vegetable crops.

Practical

Preparation of solutions of plant growth substances and their application; experiments in breaking and induction of dormancy by chemicals; induction of parthenocarpy and fruit ripening; application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables; growth analysis techniques in vegetable crops.

Suggested Readings

Bleasdale JKA. 1984. *Plant Physiology in Relation to Horticulture*. 2nd Ed. MacMillan.

Gupta US. (Ed.). 1978. *Crop Physiology*. Oxford & IBH.

Krishnamoorti HN. 1981. *Application Plant Growth Substances and Their Uses in Agriculture*. Tata-McGraw Hill.

Peter KV. (Ed.). 2008. *Basics of Horticulture*. New India Publ. Agency.

Saini RS, Sharma KD, Dhankhar OP & Kaushik RA. (Eds.). 2001. *Laboratory Manual of Analytical Techniques in Horticulture*. Agrobios.

Wien HC. (Ed.). 1997. *The Physiology of Vegetable Crops*. CABI.

5.VSC 505 SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS 2+1

Objective

To educate principles and methods of quality seed and planting material production in vegetable crops.

Theory

UNIT I

Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.

UNIT II

Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production.

UNIT III

Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

UNIT VI

Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.

UNIT V

Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra, vegetatively propagated vegetables.

Practical

Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and notification procedures of varieties; floral biology; rouging of off-type; methods of hybrid seed production in important vegetable and spice crops; seed extraction techniques; handling of seed processing and seed testing equipments; seed sampling; testing of vegetable seeds for seed purity, germination, vigour and health; visit to seed processing units, seed testing laboratory and seed production farms.

Suggested Readings

Agrawal PK & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.

Agrawal RL. (Ed.). 1997. *Seed Technology*. Oxford & IBH.

Bendell PE. (Ed.). 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publ.

Fageria MS, Arya PS & Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani.

George RAT. 1999. *Vegetable Seed Production*. 2nd Ed. CABI.

Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.

More TA, Kale PB & Khule BW. 1996. *Vegetable Seed production Technology*. Maharashtra State Seed Corp.

Rajan S & Baby L Markose. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.

Singh NP, Singh DK, Singh YK & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distributing Co.

Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.

6.VSC 506 SYSTEMATICS OF VEGETABLE CROPS 1+1

Objective

To teach morphological, cytological and molecular taxonomy of vegetable crops.

Theory

UNIT I

Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops.

UNIT II

Origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables.

UNIT III

Cytological level of various vegetable crops; descriptive keys for important vegetables.

UNIT IV

Importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops.

Practical

Identification, description, classification and maintenance of vegetable species and varieties; survey, collection of allied species and genera locally available; preparation

of keys to the species and varieties; methods of preparation of herbarium and specimens.

Suggested Readings

Chopra GL. 1968. *Angiosperms - Systematics and Life Cycle*. S. Nagin
Dutta AC. 1986. *A Class Book of Botany*. Oxford Univ. Press.
Pandey BP. 1999. *Taxonomy of Angiosperm*. S. Chand & Co.
Peter KV & Pradeepkumar T. 2008. *Genetics and Breeding of Vegetables*. (Revised), ICAR.
Soule J. 1985. *Glossary for Horticultural Crops*. John Wiley & Sons.
Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS. 2001. *Minimal Descriptors of Agri-Horticultural Crops*. Part-II:
Vegetable Crops. NBPGR, New Delhi.
Vasistha. 1998. *Taxonomy of Angiosperm*. Kalyani.
Vincent ER & Yamaguchi M. 1997. *World Vegetables*. 2nd Ed. Chapman & Hall.

7.VSC 507 PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS 2+1

Objective

To educate production technology of underutilized vegetable crops.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of:

UNIT I

Asparagus, artichoke and leek

UNIT II

Brussels's sprout, Chinese cabbage, broccoli, kale and artichoke.

UNIT III

Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu (chenopods) and chekurmanis.

UNIT IV

Elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean.

UNIT V

Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon and little gourd (kundru).

Practical

Identification of seeds; botanical description of plants; layout and planting; cultural practices; short-term experiments of underexploited vegetables.

Suggested Readings

Bhat KL. 2001. *Minor Vegetables - Untapped Potential*. Kalyani.
lndira P & Peter KV. 1984. *Unexploited Tropical Vegetables*. Kerala Agricultural University, Kerala.
Peter KV. (Ed.). 2007-08. *Underutilized and Underexploited Horticultural Crops*. Vols. I-IV. New India Publ. Agency.
Rubatzky VE & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall

Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS. 2001. *Minimal Descriptors of Agri-Horticultural Crops*. Part-II:
Vegetable Crops. NBPGR, New Delhi.

8. VSC 508 ORGANIC VEGETABLE PRODUCTION TECHNOLOGY 1+1

Objective

To educate principles, concepts and production of organic farming in vegetable crops.

Theory

UNIT I

Importance, principles, perspective, concept and component of organic production of vegetable crops.

UNIT II

Organic production of vegetables crops, *viz.*, solanaceous crops, cucurbits, cole crops, root and tuber crops.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavvya, Biodynamics, preparation etc Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, waster management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

Dahama AK. 2005. *Organic Farming for Sustainable Agriculture*. 2nd Ed. Agrobios.
Gehlot G. 2005. *Organic Farming; Standards, Accreditation Certification and Inspection*. Agrobios.
Palaniappan SP & Annadorai K. 2003. *Organic Farming, Theory and Practice*. Scientific Publ.
Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops*. New India Publ. Agency.
Shivashankar K. 1997. *Food Security in Harmony with Nature*. 3rd IFOAMASIA, Scientific Conf.. 1- 4 December, 1997, UAS, Bangalore.

Ph.D COURSES

1.VSC 601 ADVANCES IN VEGETABLE PRODUCTION 2+1

Objective

To keep abreast with latest developments and trends in production technology of vegetable crops.

Theory

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of:

UNIT I

Tomato, brinjal, chilli, sweet pepper and potato

UNIT II

Cucurbits, cabbage, cauliflower and knol-khol

UNIT III

Bhendi, onion, peas and beans, amaranthus and drumstick

UNIT IV

Carrot, beet root and radish

UNIT V

Sweet potato, tapioca, elephant foot yam and taro

Practical

Seed hardening treatments; practices in indeterminate and determinate vegetable growing and organic gardening; portrays and ball culture; diagnosis of nutritional and physiological disorders; analysis of physiological factors like anatomy; photosynthesis; light intensity in different cropping situation; assessing nutrient status, use of plant growth regulators; practices in herbicide application; estimating water requirements in relation to crop growth stages, maturity indices; dryland techniques for rainfed vegetable production; production constraints; analysis of different cropping system in various situation like cold and hot set; vegetable waste recycling management; quality analysis ;marketing survey of the above crops; visit to vegetable and fruit mals and packing houses.

Suggested Readings

Bose TK & Som NG. 1986. *Vegetable Crops of India*. Naya Prokash.

Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.

Brewster JL. 1994. *Onions and other Vegetable Alliums*. CABI.

FFTC. *Improved Vegetable Production in Asia*. Book Series No. 36.

Ghosh SP, Ramanujam T, Jos JS, Moorthy SN & Nair RG. 1988. *Tuber Crops*. Oxford & IBH.

Gopalakrishnan TR. 2007. *Vegetable Crops*. New India Publishing Agency.

Kallo G & Singh K. (Ed.). 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals & Book Publ. House.

Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S & Pallai SV. 1996. *Tropical Tuber Crops, Problems, Prospects and Future Strategies*. Oxford & IBH.
Sin MT & Onwueme IC. 1978. *The Tropical Tuber Crops*. John Wiley & Sons.
Singh NP, Bhardwaj AK, Kumar A & Singh KM. 2004. *Modern Technology on Vegetable Production*. International Book Distr. Co.
Singh PK, Dasgupta SK & Tripathi SK. 2006. *Hybrid Vegetable Development*. International Book Distr. Co.

2.VSC 602 ADVANCES IN BREEDING OF VEGETABLE CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of:

UNIT I

Tomato, brinjal, chilli, sweet pepper and potato

UNIT II

Cucurbits, Cabbage, cauliflower and knol-khol

UNIT III

Bhendi, onion, peas and beans, amaranthus and drumstick

UNIT IV

Carrot, beet root and radish

UNIT V

Sweetpotato, tapioca, elephant foot yam and taro

Practical

Designing of breeding experiments, screening techniques for abiotic stresses, screening and rating for pest, disease and nematode resistance, estimation of quality and processing characters, screening for-quality improvement, estimation of heterosis and combining ability, induction and identification of mutants and polyploids, distant hybridization and embryo rescue techniques.

Suggested Readings

Acta Horticulture. Conference on Recent Advance in Vegetable Crops. Vol. 127.
Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
Chadha KL. 2001. *Hand Book of Horticulture*. ICAR.
Dhillon BS, Tyagi RK, Saxena S & Randhawa GJ. 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publ. House.
Janick JJ. 1986. *Horticultural Science*. 4th Ed. WH Freeman & Co.
Kaloo G & Singh K. 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals and Book Publ. House.

Kaloo G. 1994. *Vegetable Breeding*. Vols. I-III. Vedams eBooks.
Peter KV & Pradeep Kumar T. 2008. *Genetics and Breeding of Vegetables*. (Revised Ed.). ICAR.
Ram HH. 2001. *Vegetable Breeding*. Kalyani.

3.VSC 603 PROTECTED CULTIVATION OF VEGETABLE CROPS 1+1

Objective

To impart latest knowledge in growing of vegetable crops under protected environmental condition.

Theory

Crops: Tomato, capsicum, cucumber, melons and lettuce

UNIT I

Importance and scope of protected cultivation of vegetable crops; principles used in protected cultivation, energy management, low cost structures; training methods; engineering aspects.

UNIT II

Regulatory structures used in protected structures; types of greenhouse/polyhouse/nethouse, hot beds, cold frames, effect of environmental factors, *viz.* temperature, light, CO_2 and humidity on growth of different vegetables, manipulation of CO_2, light and temperature for vegetable production, fertigation.

UNIT III

Nursery raising in protected structures like poly-tunnels, types of benches and containers, different media for growing nursery under cover.

UNIT IV

Regulation of flowering and fruiting in vegetable crops, technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, training and staking in protected crops, varieties and hybrids for growing vegetables in protected structures.

UNIT V

Problem of growing vegetables in protected structures and their remedies, insect and disease management in protected structures; soil-less culture, use of protected structures for seed production.

Practical

Study of various types of structures, methods to control temperature, CO_2 light, media, training and pruning, maintenance of parental lines and hybrid seed production of vegetables, fertigation and nutrient management, control of insect-pests and disease in greenhouse; economics of protected cultivation, visit to established green/polyhouse/net house/shade house in the region.

Suggested Readings

Anonymous 2003. *Proc. All India Seminar on Potential and Prospects for Protective Cultivation*. Organised by Institute of Engineers, Ahmednagar. Dec.12-13, 2003.
Chandra S & SomV. 2000. *Cultivating Vegetables in Green House*. *Indian Horticulture* 45: 17-18.
Prasad S & Kumar U. 2005. *Greenhouse Management for Horticultural Crops*. 2nd Ed. Agrobios.
Tiwari GN. 2003. *Green House Technology for Controlled Environment*. Narosa Publ. House.

4.VSC 604 BIOTECHNOLOGY IN VEGETABLE CROPS 2+1

Objective

To teach advances in biotechnology for improvement of vegetable crops.

Theory

Crops: Tomato, eggplant, hot and sweet pepper, potato, cabbage, cauliflower, tapioca, onion, cucurbits.

UNIT I

In vitro culture methods and molecular approaches for crop improvement in vegetables, production of haploids, disease elimination in horticultural crops, micro grafting, somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II

Protoplast culture and fusion; construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation.

UNIT III

In vitro mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV

Quality improvement, improvement for biotic and abiotic stresses, transgenic plants.

UNIT V

Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

Practical

Establishment of axenic explants, callus initiation and multiplication, production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids; Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods, molecular characterization of transgenic plants.

Suggested Readings

Bajaj YPS. (Ed.). 1987. *Biotechnology in Agriculture and Forestry*. Vol.XIX. *Hitech and Micropropagation*. Springer.

Chadha KL, Ravindran PN & Sahijram L. (Eds.). 2000. *Biotechnology of Horticulture and Plantation Crops*. Malhotra Publ. House.

Debnath M. 2005. *Tools and Techniques of Biotechnology*. Pointer Publ. Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall.

Gorden H & Rubsell S. 1960. *Hormones and Cell Culture*. AB Book Publ.

Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman (Universal Press).

Keshavachandran R et al. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. New India Publ. Agency.

Panopoulas NJ. (Ed.). 1981. *Genetic Engineering in Plant Sciences*. Praeger Publ.

Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash.

Pierik RLM. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.

Prasad S. 1999. *Impact of Plant Biotechnology on Horticulture*. 2nd Ed.Agro Botanica.

Sharma R. 2000. *Plant Tissue Culture*. Campus Books.

Singh BD.2001. *Biotechnology*. Kalyani.

Skoog Y & Miller CO. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Cultured in vitro.* Attidel. II Symp. on
Biotechnology Action of Growth Substance.
Vasil TK, Vasi M, While DNR & Bery HR. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Planum Press.
Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V.

5.VSC 605 SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE CROPS 2+1

Objective

To educate the recent trends in the certification, processing and storage of vegetable crops.

Theory

UNIT I

Seed certification, objectives, organization of seed certification, minimum seed certification standards of vegetable crops, field inspection, specification for certification.

UNIT II

Seed processing, study of seed processing equipments seed cleaning and upgrading, Seed packing and handling, equipment used for packaging of seeds, procedures for allocating lot number.

UNIT III

Pre-conditioning, seed treatment, benefits, types and products, general principles of seed storage, advances in methods of storage, quality control in storage, storage containers, seed longevity and deterioration, sanitation, temperature and relative humidity control.

UNIT IV

Seed testing; ISTA rules for testing, moisture, purity germination, vigor test, seed sampling, determination of genuineness of varieties, seed viability, seed health testing; seed dormancy and types of dormancy, factors responsible for dormancy.

UNIT V

Seed marketing, demand forecast, marketing organization, economics of seed production; farmers' rights, seed law enforcement, seed act and seed policy.

Practical

Seed sampling, purity, moisture testing, seed viability, seed vigor tests, seed health testing, seed cleaning, grading and packaging; handling of seed testing equipment and processing machines; seed treatment methods, seed priming and pelleting; field and seed inspection, practices in rouging, seed storage, isolation distances, biochemical tests, visit to seed testing laboratories and processing plants, mixing and dividing instruments, visit to seed processing unit and warehouse visit and know about sanitation standards.

Suggested Readings

Agrawal PK & Dadlani M. 1992. *Tecniques in Seed Science and Technology*. South Asian Publ.
Singh N, Singh DK, Singh YK & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distr. Co.
Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.
Tanwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, GOI, New Delhi.
Rajan S & Baby L Markose 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.

6.VSC 606 ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

UNIT I

Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of antitranspirants.

UNIT II

Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT III

Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices.

UNIT IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT V

Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

Practical

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops, measurement of tolerance to various stresses in vegetable crops, short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions, and use of chemicals for alleviation of different stresses.

Suggested Readings

Dwivedi P & Dwivedi RS. 2005. *Physiology of Abiotic stress in Plants*. Agrobios.
Lerner HR (Ed.). 1999. *Plant Responses to Environmental Stresses*. Marcel Decker.
Maloo SR. 2003. *Abiotic Stresses and Crop Productivity*. Agrotech Publ. Academy.

List of Journals

- American Journal of Horticultural Sciences
- American Potato Growers
- American Scientist
- Annals of Agricultural Research
- Annual Review of Plant Physiology
- California Agriculture
- Haryana Journal of Horticultural Sciences
- HAU Journal of Research
- Horticulture Research
- HortScience
- IIVR Bulletins
- Indian Horticulture
- Indian Journal of Agricultural Sciences
- Indian Journal of Horticulture
- Indian Journal of Plant Physiology

- Journal of American Society for Horticultural Sciences
- Journal of Arecanut and Spice Crop
- Journal of Food Science and Technology
- Journal of Plant Physiology
- Journal of Post-harvest Biology and Technology
- Post-harvest Biology and Technology
- Scientia Horticulturae
- Seed Research
- Seed Science
- South Indian Horticulture
- Vegetable Grower
- Vegetable Science

Suggested Broad Topics for Master's and Doctoral Research

- Organic farming in vegetable crops
- Application of molecular markers in genetic improvement of vegetable crops
- Development of transgenic vegetables
- Growing vegetables under protected conditions
- Mulching in vegetable crops
- Micronutrients in vegetable crops
- Screening of vegetable s against abiotic stress
- Hi-tech methods for raising nursery of vegetable crops
- Dry land and coastal farming
- Drip/micro irrigation in vegetable crops
- Fertigation in vegetable crops
- Research on physiological disorders in vegetable crops
- Breeding for quality improvement
- Breeding for insect-pest and disease resistance
- Breeding for extending shelf life of vegetable crops
- Minimal processing of vegetables
- Concept of quality control in vegetable seed production
- Integrated nutrients management in vegetable crops
- Breeding for industrial and processing of vegetable crops
- Research on water management in vegetable crops
- Research on home storage of vegetable crops
- Hi-tech home gardening

XIII POMOLOGY AND FLORICULTURE

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
FSC 501*	TROPICAL AND DRY LAND FRUIT PRODUCTION	2+1
FSC 502*	SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION	2+1
FSC 503	BIODIVERSITY AND CONSERVATION OF FRUIT CROPS	2+1
FSC 504	CANOPY MANAGEMENT IN FRUIT CROPS	1+1
FSC 505	PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS	2+1
FSC 506	BREEDING OF FRUIT CROPS	2+1
FSC 508	GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS	2+1
FSC 509	BIOTECHNOLOGY OF HORTICULTURAL CROPS	2+1
FSC 510	ORGANIC HORTICULTURE	1+1
FSC 511	PROTECTED FRUIT CULTURE	2+1
FSC 512	*GAP* FOR HORTICULTURAL CROPS	1+0
FSC 513	CLIMATE MANAGEMENT IN HORTICULTURAL PRODUCTION	1+0
FLA.501	BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS	2+1
FLA.502*	PRODUCTION TECHNOLOGY OF CUT FLOWERS	2+1
FLA.503	PRODUCTION TECHNOLOGY OF LOOSE FLOWERS	2+1
FLA.504*	LANDSCAPING AND OR NAMENTAL GARDENING	2+1
FLA.505	PROTECTED FLORICULTURE	2+1
FLA.506	VALUE ADDITION IN FLOWERS	2+1
FLA.507	TURFING AND TURF MANAGEMENT	2+1
FLA.508	CAD FOR OUTDOOR AND INDOOR SCAPING	2+1
FSC 591/ FLA 591	MASTER'S SEMINAR	0+1
FSC 599/ FLA 599	MASTER'S RESEARCH	20
FSC 601	ADVANCES IN BREEDING OF FRUIT CROPS	2+1
FSC 602**	ADVANCES IN PRODUCTION OF FRUIT CROPS	2+1
FSC 603	ADVANCES IN GROWTH REGULATION OF FRUIT CROPS	2+1
FSC 605	BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS	2+1
FLA 601	ADVANCES IN BREEDING OF FLOWER CROPS	2+1
FLA 602**	ADVANCES IN FLOWER PRODUCTION TECHNOLOGY	2+1
FLA 603	ADVANCES IN PROTECTED AND PRECISION FLORICULTURE	1+1
FLA 604**	ADVANCES IN LANDSCAPE ARCHITECTURE	1+2
FSC 691/ FLA 691	DOCTORAL SEMINAR I	0+1
FSC 692/ FLA 692	DOCTORAL SEMINAR II	0+1
FSC 699/ FLA 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Doctoral programme

1. FSC 501 TROPICAL AND DRY LAND FRUIT PRODUCTION 2+1

Objective

To impart basic knowledge about the importance and management of tropical and dry land fruits grown in India .

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bioregulators, abiotic factors limiting fruit production, physiology of flowering, pollination fruit set and development, honeybees in cross pollination, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports.

Crops

UNIT I

Mango and Banana

UNIT II

Citrus and Papaya

UNIT III

Guava, Sapota and Jackfruit

UNIT IV

Pineapple, Annonas and Avocado

UNIT V

Aonla, Pomegranate, Phalsa and Ber, minor fruits of tropics

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.

Suggested Readings

Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. *Temperate Fruits - Horticulture* . Allied Publ.

Bose TK, Mitra SK & Sanyal D. 2001. (Eds.). *Fruits -Tropical and Subtropical* . Naya Udyog.

Chadha KL & Pareek OP. 1996. (Eds.). *Advances in Horticulture* . Vols. II- IV. Malhotra Publ. House.

Nakasone HY & Paul RE. 1998. *Tropical Fruits* . CABI.

Peter KV. 2008. (Ed.). *Basics of Horticulture* . New India Publ. Agency.

Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops* . Parts I, II. New India Publ. Agency.

Radha T & Mathew L. 2007. *Fruit Crops* . New India Publ. Agency.

Singh HP, Negi JP & Samuel JC. (Eds.). 2002. *Approaches for Sustainable Development of Horticulture* . National Horticultural Board.

Singh HP, Singh G, Samuel JC & Pathak RK. (Eds.). 2003. *Precision Farming in Horticulture* . NCPAH, DAC/PFDC, CISH, Lucknow.

2. FSC 502 SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION 2+1

Objective

To impart basic knowledge about the importance and management of subtropical and temperate fruits grown in India .

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support.

Crops

UNIT I

Apple, pear, quince, grapes

UNIT II

Plums, peach, apricot, cherries, hazlenut

UNIT III

Litchi, loquat, persimmon, kiwifruit, strawberry

UNIT IV

Nuts- walnut, almond, pistachio, pecan

UNIT V

Minor fruits- mangosteen, carambola, bael, wood apple, fig, jamun, rambutan, pomegranate

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical, subtropical, humid tropical and temperate orchards, Project preparation for establishing commercial
orchards.

Suggested Readings

Bose TK, Mitra SK & Sanyol D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical* . 3rd Ed. Vols. I, II. Naya Udyog.

Chadha KL & Pareek OP. 1996. (Eds.). *Advances in Horticulture* . Vol. I. Malhotra Publ. House.

Chadha KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management* . Malhotra Publ. House.

Janick J & Moore JN. 1996. *Fruit Breeding* . Vols.I-III. John Wiley & Sons.

Nijjar GS. 1977. (Eds.). *Fruit Breeding in India* . Oxford & IBH.

Radha T & Mathew L. 2007. *Fruit Crops* . New India Publ. Agency.

Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. *Advances in Citriculture* . Jagmander Book Agency.

3. FSC 503 BIODIVERSITY AND CONSERVATION OF FRUIT CROPS 2+1

Objective

Understanding the principles of biodiversity and strategies in germplasm conservation of fruit crops.

Theory

UNIT I

Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity.

UNIT II

Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources – conservation *in situ* and *ex situ.*

UNIT III

Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.

UNIT IV

Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group.

UNIT V

GIS and documentation of local biodiversity, Geographical indication.

Crops

Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard apple, ber, aonla, apple, pear, peach, plum, litchi, nuts, coffee, tea, rubber, cashew, coconut, cocoa, palmyrah, arecanut, oil palm and betelvine.

Practical

Documentation of germplasm – maintenance of passport data and other records of accessions; field exploration trips, exercise on *ex situ* conservation – cold storage, pollen/seed storage, cryopreservation, visits to National Gene Bank and other centers of PGR activities. Detection of genetic constitution of germplasm, core sampling, germplasm characterization using molecular techniques.

Suggested Readings

Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow* . Cambridge University Press.

Peter KV & Abraham Z. 2007. *Biodiversity in Horticultural Crops* . Vol. I. Daya Publ. House.

Peter KV. 2008. *Biodiversity of Horticultural Crops* . Vol. II. Daya Publ. House.

4. FSC 504 CANOPY MANAGEMENT IN FRUIT CROPS 1+1

Objective

To impart knowledge about the principles and practices in canopy management of fruit crops.

Theory

UNIT I

Canopy management - importance and advantages; factors affecting canopy development.

UNIT II

Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies.

UNIT III

Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion.

UNIT IV

Canopy management through plant growth inhibitors, training and pruning and management practices.

UNIT V

Canopy development and management in relation to growth, flowering, fruiting and fruit quality in apple, pear, peach and plum, grapes, passion fruits, mango, sapota, guava, citrus and ber.

Practical

Study of different types of canopies, training of plants for different canopy types, canopy development through pruning, use of plant growth inhibitors, geometry of planting; study on effect of different canopy types on production and quality of fruits.

Suggested Readings

Chadha KL & Shikhamany SD. 1999. *The Grape, Improvement, Production and Post Harvest Management* . Malhotra Publ. House.

Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops* . New India Publ. Agency.

5. FSC 505 PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS 2+1

Objective

Familiarization with principles and practices of propagation and nursery management for fruit crops.

Theory

UNIT I

Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixis, polyembryony, chimeras. Principles factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth.

UNIT II

Seed quality, treatment, packing, storage, certification, testing. Asexual propagation – rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

UNIT III

Budding and grafting – selection of elite mother plants, methods. Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank.

UNIT IV

Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro-propagules.

UNIT V

Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical

Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR. Hardening – case studies, micropropagation, explant preparation, media preparation, culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.

Suggested Readings

Hartmann HT & Kester DE. 1989. *Plant Propagation – Principles and Practices* . Prentice Hall of India.

Bose TK, Mitra SK & Sadhu MK. 1991. *Propagation of Tropical and Subtropical Horticultural Crops* . Naya Prokash.

Peter KV. (Ed.). 2008. *Basics of Horticulture* . New India Publ. Agency.

Singh SP. 1989 *Mist Propagation* . Metropolitan Book Co.

Rajan S & Baby LM. 2007. *Propagation of Horticultural Crops* . New India Publ. Agency.

Radha T & Mathew L. 2007. *Fruit Crops* . New India Publ. Agency.

6. FSC 506 BREEDING OF FRUIT CROPS 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of fruit crops.

Theory

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches for crop improvement - introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Crops

UNIT I

Mango, banana and pineapple

UNIT II

Citrus, grapes, guava and sapota

UNIT III

Jackfruit, papaya, custard apple, aonla, avocado and ber

UNIT IV

Mangosteen, litchi, jamun, phalsa, mulberry, raspberry, kokam and nuts

UNIT V

Apple, pear, plums, peach, apricot, cherries and strawberry

Practical

Characterization of germplasm, blossom biology, study of anthesis, estimating fertility status, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits, visit to research stations working on tropical, subtropical and temperate fruit improvement

Suggested Readings

Bose TK, Mitra SK & Sanyol D. (Eds.). 2002. *Fruits of India – Tropical and Sub-tropical* . 3rd Ed. Vols. I, II. Naya Udyog.

Chadha KL & Pareek OP. 1996. (Eds.). *Advances in Horticulture* . Vol. I. Malhotra Publ. House.

Chadha KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management* . Malhotra Publ. House.

Janick J & Moore JN. 1996. *Fruit Breeding* . Vols.I-III. John Wiley & Sons.

Nijjar GS. 1977. (Eds.). *Fruit Breeding in India* . Oxford & IBH.

Radha T & Mathew L. 2007. *Fruit Crops* . New India Publ. Agency.

Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. *Advances in Citriculture* . Jagmander Book Agency.

7.FSC 508 GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS 2+1

Objective

To develop understanding of growth and development of horticultural crops which have implications in their management.

Theory

UNIT I

Growth and development- definition, parameters of growth and development, growth dynamics, morphogenesis.

UNIT II

Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism vernalisation, effect of temperature, heat units, thermoperiodism.

UNIT III

Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinins, abscissic acid, ethylene, brasssinosteroids, growth inhibitors, mor phactins, role of plant growth promoters and inhibitors.

UNIT IV

Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

UNIT V

Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

Practical

Understanding dormancy mechanisms in seeds, tubers and bulbs and stratification of seeds, tubers and bulbs, visit to arid, subtropical and temperate horticultural zones to identify growth and development patterns, techniques of growth analysis, evaluation of photosynthetic efficiency under different environments, study of growth regulator functions, hormone assays, understanding ripening phenomenon in fruits and vegetables, study of impact of physical manipulations on growth and development, study of chemical manipulations on growth and development, understanding stress impact on growth and development.

Suggested Readings

Buchanan B, Gruiessam W & Jones R. 2002. *Biochemistry & MolecularBiology of Plants* . John Wiley & Sons.

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives* .Wiley.

Fosket DE. 1994. *Plant Growth and Development: a Molecular Approach* . Academic Press.

Leoplod AC & Kriedermann PE. 1985. *Plant Growth and Development* . 3 rd Ed. Mc Graw-Hill.

Peter KV. 2008. (Ed.) *Basics of Horticulture* . New India Publ. Agency.

Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: *Plants* (I. Ridge, Ed.), pp. 221-274, Oxford University Press.

Salisbury FB & Ross CW. 1992. *Plant Physiology* . 4th Ed. Wadsworth Publ.

8. FSC 509 BIOTECHNOLOGY OF HORTICULTURAL CROPS 2+1

Objective

Understanding the principles, theoretical aspects and developing skills in biotechnology of horticultural crops.

Theory

UNIT I

Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.

UNIT II

Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis.

UNIT III

Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, ex vitro, establishment of tissue cultured plants.

UNIT IV

Physiology of hardening - hardening and field transfer, organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion.

UNIT V

Construction and identification of somatic hybrids and cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops.

Practical

An exposure to low cost, commercial and homestead tissue culture laboratories, media preparation, inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus, sub-culturing, techniques on anther, ovule, embryo culture, somaclonal variation, *in vitro* mutant selection against abiotic stress, protoplast culture, fusion technique, development of protocols for mass multiplication, project development for establishment of commercial tissue culture laboratory.

Suggested Readings

Bajaj YPS. (Ed.).1989. *Biotechnology in Agriculture and Forestry* . Vol. V, *Fruits* . Springer.

Brown TA. 2001. *Gene Cloning and DNA Analysis and Introduction.* Blackwell Publ.

Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology –Concepts, Methods and Applications.* Oxford & IBH.

Gorden H & Rubsell S. 1960. *Hormones and Cell Culture* . AB Book Publ.

Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer* Orient & Longman (Universal Press).

Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops* . Vols. I, II. New India Publ. Agency.

Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. *Biotechnology of Horticultural Crops* . Vols. I-III. Naya Prokash.

Pierik RLM. 1987. *In vitro Culture of Higher Plants* . Martinus Nijhoff Publ.

Skoog F & Miller CO. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro. Symp. Soc. Exp. Biol.* 11: 118-131

Vasil TK, Vasi M, While DNR & Bery HR.1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture* . Planum Press.
Williamson R. 1981-86. *Genetic Engineering* . Vols. I-V. Academic Press.

9. FSC 510 ORGANIC HORTICULTURE 1+1

Objective

To develop understanding of organic horticulture production system including GAP.

Theory

UNIT I

Organic horticulture – definition, synonyms and misnomers, principles, methods, merits and demerits.

UNIT II

Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biofertilizers, biodynamics and the recent developments.

UNIT III

EM technology and its impact in organic horticulture, indigenous practices of organic farming, sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, organic horticulture in quality improvement.

UNIT IV

GAP - Principles and management, HACCP exercise, certification of organic products and systems, agencies involved at national and international levels, standards evolved by different agencies.

UNIT V

Constraints in certification, organic horticulture and export, IFOAM and global scenario of organic movement, post-harvest management of organic produce.

Practical

Features of organic orchards, working out conversion plan, Input analysis-manures, nutrient status assessment of manures, biocomposting, biofertilizers and their application, panchagavya preparation and other organic nutrients application, methods of preparation of compost, vermicompost, green manuring, preparation of neem products and application, BD preparations and their role, EM technology and products, biological/natural control of pests and diseases, soil solarization, frame work for GAP, case studies, HACCP analysis, residue analysis in organic products, documentation for certification, visit to fields cultivated under organic practices

Suggested Readings

Claude A, Vandana S, Sultan I, Vijaya L, Korah M & Bernard D. 2000. *The Organic Farming Reader* . Other Indian Press, Goa.
Gaur AC, Neblakantan S & Dargan KS. 1984 *Organic Manures* . ICAR.
Lampkin N & Ipswich. 1990. *Organic Farming* . Farming Press. London.
Lampkin NH & Padel S. 1992. *The Economics of Organic Farming – An International Perspective.* CABI.
Palaniappan & Annadurai. 2008. *Organic Farming- Theory and Practise* . Scientific Publ.
Peter KV. 2008. (Ed.). *Basics of Horticulture* . New India Publ. Agency. New Delhi.
Rao S. 1977. *Soil Microorganism and Plant Growth* . Oxford & IBH.

10. FSC 511 PROTECTED FRUIT CULTURE 2+1

Objective

Understanding the principles, theoretical aspects and developing skills in protected cultivation of fruit crops.

Theory

UNIT I

Greenhouse – World scenario, Indian situation: present and future, Different agro-climatic zones in India, Environmental factors and their effects on plant growth.

UNIT II

Basics of greenhouse design, different types of structures – glasshouse, shade net, poly tunnels - Design and development of low cost greenhouse structures.

UNIT III

Interaction of light, temperature, humidity, CO_2 , water on crop regulation - Greenhouse heating, cooling, ventilation and shading.

UNIT IV

Types of ventilation- Forced cooling techniques - Glazing materials - Micro irrigation and Fertigation.

UNIT V

Automated greenhouses, microcontrollers, waste water recycling, Management of pest and diseases – IPM.

Practical

Designs of greenhouse, low cost poly tunnels, nethouse- Regulation of light, temperature, humidity in greenhouses, media, greenhouse cooling systems, ventilation systems, fertigation systems, special management practices, project preparation for greenhouses, visit to greenhouses.

Suggested Readings

Aldrich RA & Bartok JW. 1994. *Green House Engineering* . NRAES, Riley, Robb Hall, Cornell University, Ithaca, New York. Bhatcharjee BS. 1959. *Rose Growing in Tropics* . Thackarspink & Co. Laurie A, Kiplingr DD & Nelson KS. 1968. *Commercial Flower Forcing* . McGraw-Hill.

Mears DR, Kim MK & Roberts WJ. 1971. *Structural Analysis at an Experimental Cable-supported Air Inflated Green Houses.* Trans. ASAE.

Pant V Nelson. 1991. *Green House Operation and Management* . Bali Publ.

Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2007. *Management of Horticultural Crops.* Parts I, II. New India Publ. Agency.

11. FSC 512 *GAP* FOR HORTICULTURAL CROPS 1+0

Objective

To impart comprehensive knowledge about the principles and practices of Good Agricultural Practises (GAP) for horticultural crops.

Theory

UNIT I

Genesis of GAP – definition/description, components listed by FAO, frame work.

UNIT II

Management of site history and soil, crop and fodder production, IPM, INM, IWM, irrigation water, crop production and protection. Identification of w ays of improving the productivity profitability, and resource efficiency, harvest and post-harvest handling.

UNIT III

Animal production, product certification, animal waste management, animal health and welfare, harvest.

UNIT IV

On farm processing, storage, energy and waste management, human health, welfare, safety, wild life benefits.

UNIT V

Institutions involved in GAP certification. Indian agencies, EUREPGAP (European Retail Producers Group- Good Agricultural Practices), EUREP etc.

Suggested Readings

Peter KV. 2008. *Basics in Horticulture* . New India Publ. Agency.

12. FSC 513 CLIMATE MANAGEMENT IN HORTICULTURAL PRODUCTION 1+0

Objective

To develop understanding about the impact and management of climate in horticultural production.

Theory

UNIT I

Introduction to climate change. Factor s directly connected to climate change, average temperature, change in rainfall amount and patterns, rising atmospheric concentrations of CO_2 , pollution levels such as tropospheric ozone, change in climatic variability and extreme events like receding of glaciers in Himalayas.

UNIT II

Sensors for climate registration and crop monitoring, phytomonitoring and biosensors, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, insect pests, longer growing seasons and shifts in plant hardiness for perennial fruit crops, flowering plants and other plant species.

UNIT III

Impact of climate changes on invasive insect, disease, weed, pests, horticulture yield, quality and sustainability, climate management in field production – mulching - use of plastic- windbreak- spectral changes- frost protection. Climate management in greenhouse- heating - vents – CO_2 injection - screens - artificial light.

UNIT IV

Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems around the world. Special protected cultivation now and in the future, growth chambers, production in space, biosphere, future aspects of closed production, future greenhouse, use of LED as artificial light, future sensor types etc. clean development mechanism, role of tropical trees.

Suggested Readings

Peter KV. 2008. (Ed.). *Basics of Horticulture* . New India Publ. Agency.

Rao GSLHV, Rao GGSN, Rao VUM & Ramakrishnan YS. 2008. *Climate Change and Agriculture over India* . ICAR.

Rao GSLHV. 2008. *Agricultural Meteorology* . Prentice Hall.

13. FLA 501 BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of flower crops and ornamental plants.

Theory

UNIT I

Principles -- Evolution of varieties, origin, distribution, genetic resources, genetic divergence- Patents and Plant Variety Protection in India.

UNIT II

Genetic inheritance -- of flower colour, doubleness, flower size, fragrance, post harvest life.

UNIT III

Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants-- introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops.

UNIT IV

Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, liliums, nerium.

UNIT V

Breeding constraints and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy) and ornamental foliages– Introduction and selection of plants for waterscaping and xeriscaping.

Practical

Description of botanical features– Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production-Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture* . Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Chadha KL & Choudhury B.1992. *Ornamental Horticulture in India* . ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Chaudhary RC. 1993. *Introduction to Plant Breeding.* Oxford & IBH.

Singh BD. 1990. *Plant Breeding* . Kalyani.

14. FLA 502 PRODUCTION TECHNOLOGY OF CUT FLOWERS 2+1

Objective

To impart basic knowledge about the importance and production technology of cut flowers grown in India.

Theory

UNIT I

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices.

UNIT II

Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO_2 on growth and flowering.

UNIT III

Flower production – water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes.

UNIT IV

Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation.

UNIT V

Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

Crops: Rose, tulip, chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, curcumas, ornamental *Musa*, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliages and fillers.

Practical

Botanical description of varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

Suggested Readings

Arora JS. 2006. *Introductory Ornamental horticulture* . Kalyani.

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture* . Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

Chadha KL & Chaudhury B. 1992. *Ornamental Horticulture in India* . ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Lauria A & Ries VH. 2001. *Floriculture – Fundamentals and Practices.* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Rajeevan, P.K., Sobhana, A., Bhaskar, J., Swapna, S and Bhattacharjee, S.K 2002. Orchids. Technical Bulletin. AICRP on Floriculture ,ICAR, New Delhi. p.62

Rajeevan, P.K. Singh, K.P. and Valsalakumari P.K. 2003 *ed*. *Bulbous Ornamentals.* Indian Society of Ornamental Horticulture Division of Floriculture & Landscaping, IARI, New Delhi. p. 187.

Rajeevan, P.K., Valsalakumari, P.K., Geetha, C.K., and Sudhadevi, P.K (ed) 2006. *Reflections on Indian Floribusiness*. KAU, Vellanikkara. p. 211.

Rajeevan, P.K., Valsalakumari, P.K., Geetha, C.K., Leena Ravidas., Vinod Kumar and Bhattacharjee, S.K. 2002. Anthurium. Technical Bulletin. AICRP on Floriculture, ICAR, New Delhi. p. 42.

Rajeevan, P.K., Valsalakumari, P.K. and Misra, R.L. 2003 *ed*. *One Hundred Research Papers in Floriculture.* Indian Society of Ornamental Horticulture Division of Floriculture & Landscaping, IARI, New Delhi. p. 415.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India* . Allied Publ.
Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

15. FLA 503 PRODUCTION TECHNOLOGY OF LOOSE FLOWERS 2+1

Objective

To impart basic knowledge about the importance and management of loose flowers grown in India.

Theory

UNIT I

Scope of loose flower trade, Significance in the domestic market/export, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques

UNIT II

Soil and climate requirements, field preparation, systems of planting, precision farming techniques.

UNIT III

Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM.

UNIT IV

Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packing and storage, value addition, concrete and essential oil extraction, trasportation and marketing, export potential, institutional support, Agri Export Zones.

Crops: Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, barleria, celosia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, *Lilium*, tecoma, champaka, pandanus).

Practical

Botanical description of species and varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, storage and cold chain, project preparation for regionally important commercial loose flowers, visits to fields, essential oil extraction units and markets.

Suggested Readings

Arora JS. 2006. *Introductory Ornamental Horticulture* . Kalyani.
Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture* . Vols. I-VI. Pointer Publ.
Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.
Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
Chadha KL & Chaudhury B.1992. *Ornamental Horticulture in India* . ICAR.
Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.
Lauria A & Ries VH. 2001. *Floriculture – Fundamentals and Practices.* Agrobios.
Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.
Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India.* Allied Publ.

Sheela VL. 2007. *Flowers in Trade* . New India Publ. Agency.
Valsalakumari PK, Rajeevan PK, Sudhadevi PK & Geetha CK. 2008. *Flowering Trees* . New India Publ. Agency.

16. FLA 504 LANDSCAPING AND ORNAMENTAL GARDENING 2+ 1

Objective

Familiarization with principles and practices of landscaping and ornamental gardening.

Theory

UNIT I

Landscape designs, types of gardens, English, Mughal, Japanese, Persian,
Spanish, Italian, Vanams, Buddha garden; Styles of garden, formal, informal and free style gardens.

UNIT II

Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates.

UNIT III

Garden plant components, arboretum, shrubbery, fernery, palmatum, arches
and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental
plants.

UNIT IV

Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves.

UNIT V

Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practical

Selection of ornamental plants **,** practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Suggested Readings

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.
Nambisan KMP.1992. *Design Elements of Landscape Gardening* . Oxford & IBH.
Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India* . Allied Publ.
Sabina GT & Peter KV. 2008. *Ornamental Plants for Gardens* . New India Publ. Agency.
Valsalakumari et al. 2008. *Flowering Trees* . New India Publ. Agency. Woodrow MG.1999. *Gardening in India.* Biotech Books.

17. FLA 505 PROTECTED FLORICULTURE 2 + 1

Objective

Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.

Theory

UNIT I

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation.

UNIT II

Environment control – management and manipulation of temperature, light, humidity, air and CO_2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation.

UNIT III

Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM.

UNIT IV

Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards.

Practical

Study of various protected structures, practices in design, layout and erection of different types of structures, practices in preparatory operations, soil decontamination techniques, practices in environmental control systems, practices in drip and fertigation techniques, special horticultural practices, determination of harvest indices and harvesting methods, post-harvest handling, packing methods, project preparation, visit to commercial greenhouses.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture* . Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Nelson PV. 1978. *Green House Operation and Management* . Reston Publ. Co.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India* . Allied Publ.

Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

18. FLA 506 VALUE ADDITION IN FLOWERS 2+1

Objective

To develop understanding of the scope and ways of value addition in flowers.

Theory

UNIT I

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management.

UNIT II

Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations.

UNIT III

Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage.

UNIT IV

Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications.

Practical

Practices in preparation of bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers; Techniques in flower arrangement; Techniques in floral decoration; Identification of plants for dry flower making; Practices in dry flower making; Preparation of dry

flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths, etc.; Visit to dry flower units, concrete and essential oil extraction units.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture* . Vols. I-VI. Pointer Publ.

Chadha KL.1995. *Advances in Horticulture* . Vol.XII. Malhotra Publ. House.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

19. FLA 507 TURFING AND TURF MANAGEMENT 2+1

Objective

To develop understanding of the principles and management of turfing.

Theory

UNIT I

Prospects of landscape industry; History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment.

UNIT II

Turf grasses - Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement-Adaptation; Turfing for roof gardens.

UNIT III

Preparatory operations; Growing media used for turf grasses - Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing.

UNIT IV

Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing -- mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

UNIT V

Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

Practical

Identification of turf grasses, Preparatory operations in turf making, Practices in turf establishment, Layout of macro and micro irrigation systems, Water and nutrient management; Special practices – mowing, raking, rolling, soil top dressing, weed management; Biotic and abiotic stress management; Project preparation for turf establishment, visit to IT parks, model cricket and golf grounds, airports, corporates, Govt. organizations; Renovation of lawns; Turf economics. **Suggested Readings**

Nick-Christians 2004. *Fundamentals of Turfgrass Management*. www.amazon.com

20. FLA 508 CAD FOR OUTDOOR AND INDOOR SCAPING 2+1

Objective

To impart basic knowledge about the operation of Computer Aided Designing (CAD) in landscape garden designing.

Theory

UNIT I

Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing.

UNIT II

2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects.

UNIT III

Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout.

UNIT IV

3D drawing methods, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

UNIT V

ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

Practical

Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments, Isometric drawings, Using productivity tools, Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden, Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD, Organization, dimensioning, detailing and visualization tools with ARCHICAD, Using Photoshop package for 3D picture insertion, Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots.

Suggested Readings

Christine Wein-Ping Yu 1987. *Computer-aided Design: Application to Conceptual Thinking in Landscape Architecture* . amazon.com

Ph.D COURSES

1. FSC 601 ADVANCES IN BREEDING OF FRUIT CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of fruit crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits, recent advances in crop improvement efforts-introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops.

Crops

UNIT I

Mango and banana

UNIT II

Papaya, grapes and citrus

UNIT III

Guava and sapota

UNIT IV

Pineapple and avocado

UNIT V

Apple, pear, plums, peaches, apricot, cherries and strawberry

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination-isozyme techniques-survey and clonal selection, observations on pest, disease and stress reactions in inbreds and hybrids, use of mutagenes and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding fruit crops and in-vitro breeding techniques.

Suggested Readings

Bose TK, Mitra SK & Sanyol D. (Ed.). 2002 . *Fruits of India – Tropical andSub-tropical* . 3 rd Ed. Vols. I, II. Naya Udyog.

Chadha KL & Pareek OP. (Eds.). 1996. *Advances in Horticulture* . Vol. I. Malhotra Publ. House.

Chadha KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management* . Malhotra Publ. House.

Gowen S. 1996. *Banana and Plantains* . Chapman & Hall.

Janick J & Moore JN. 1996. *Fruit Breeding* . Vols.I-III. John Wiley & Sons.

Nijjar GS. (Ed.). 1977. *Fruit Breeding in India* . Oxford & IBH.

Radha T & Mathew L. 2007. *Fruit Crops* . New India Publ. Agency.

Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. *Advances in Citriculture* . Jagmander Book Agency.

Stover RH & Simmonds NW. 1991. *Bananas* . Longman.

2. FSC 602 ADVANCES IN PRODUCTION OF FRUIT CROPS 2+1

Objective

To keep abreast with latest developments and trends in production technology of fruit crops.

Theory

National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling , Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, , Total quality management(TQM) - Current topics.

Crops

UNIT I

Mango and banana

UNIT II

Papaya, grapes and citrus

UNIT III

Guava, sapota, pomegranate and aonla

UNIT IV

Pineapple, avocado, jack fruit and fig

UNIT V

Apple, pear, plums, strawberry, peach, apricot, cherries and nut crops

Practical

Survey of existing fruit cropping systems and development of a model cropping system, Estimating nutrient deficiency- estimation of water use efficiency, soil test-crop response correlations, practices in plant growth regulation, studying physiological and biochemical responses, quality analysis.

Suggested Readings

Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. *Temperate Fruits – Horticulture* . Allied Publ.

Bose TK, Mitra SK & Sanyal D. (Eds.). 2001. *Fruits -Tropical and Subtropical* . Naya Udyog.

Bose TK, Mitra SK, Farooqi AA & Sadhu MK. 1999. *Tropical Horticulture.* Vol. I. Naya Prokash.

Chadha KL & Pareek OP. (Eds.).1996. *Advances in Horticulture* . Vols. II-IV. Malhotra Publishing House.

Chadha KL. 2001. *Handbook of Horticulture* . ICAR.

Nakasone HY & Paull RE. 1998 . *Tropical Fruits* . CABI.

Radha T & Mathew L. 2007. *Fruit Crops* . New India Publ. Agency.

3. FSC 603 ADVANCES IN GROWTH REGULATION OF FRUIT CROPS 2+1

Objective

Appraisal on the advances in growth regulation of fruit crops.

Theory

UNIT I

Ecophysiological influences on growth and development of fruit crops- flowering, fruit set- Crop load and assimilate partitioning and distribution.

UNIT II

Root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants.

UNIT III

Absorption, translocation and degradation of phytohormones – internal and external factors influencing hor monal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

UNIT IV

Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season
production.

UNIT V

Flower drop and thinning, fruitset and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation-current topics.

Practical

Root- shoot studies, quantifying the physiological and biochemical effects of physical and chemical growth regulation, bioassay and isolation through chromatographic analysis for auxins, gibberellins, experiments on growth regulation during propagation, dormancy, flowering, fruitset and fruit development stages.

Suggested Readings

Buchanan B, Gruiessam W & Jones R. 2002. *Biochemistry & MolecularBiology of Plants* . John Wiley & Sons.

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives* . Wiley.

Fosket DE. 1994. *Plant Growth and Development: A Molecular Approach* .Academic Press.

Leoplod AC & Kriedermann PE. 1985. *Plant Growth and Development* . 3rd Ed. McGraw-Hill.

Radha T & Mathew L. 2007. *Fruit Crops* . New India Publ. Agency.

Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: *Plants* (I. Ridge, Ed.), pp. 221-274, Oxford University Press.

Salisbury FB & Ross CW. 1992. *Plant Physiology* . 4th Ed. Wadsworth Publ.

4. FSC 605 BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of biotic and abiotic stress management in horticultural crops.

Theory

UNIT I

Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).

UNIT II

Pollution - increased level of CO_2 , industrial wastes, impact of stress in horticultural crop production, stress indices, physiological and biochemical factors associated with stress, horticultural crops suitable for different stress situations.

UNIT III

Crop modeling for stress situations, cropping system, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stress and their impact on crop growth and productivity.

UNIT IV

Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers.

UNIT V

Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, cropping systems, stability and sustainability indices.

Practical

Seed treatment /hardening practices, container seedling production, analysis of soil moisture estimates (FC, ASM, PWP), analysis of plant stress factors, RWC, chlorophyll flurosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations, influence of stress on growth and development of seedlings and roots, biological efficiencies, WUE, solar energy conversion and efficiency, crop growth sustainability indices, economics of stress management, visit to orchards and water shed locations.

Suggested Readings

Blumm A. 1988. *Plant Breeding for Stress Environments* . CRC.

Christiansen MN & Lewis CF. 1982. *Breeding Plants for Less Favourable Environments.* Wiley Inter. Science.

Gupta US. 1990. *Physiological Aspects of Dry Farming* .

Hsiao TC. 1973. Plant Responses to Water Stress. *Ann. Rev. Plant Physiology* 24: 519-570.

Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: *Adaptation of Plants to Water and High Temperature Stress* . John Wiley & Sons.

Levitt J. 1972. *Response of Plants to Environmental Stresses* . Academic Press.

Maloo SR. 2003. *Abiotic Stress and Crop Productivity* . Agrotech Publ. Academy.

Mussell H & Staples R. 1979. *Stress Physiology in Crop Plants* . Wiley Inter. Science.

Nickell LG. 1983. *Plant Growth Regulating Chemicals* . CRC.

Peter KV. (Ed.). 2008. *Basics of Horticulture* . New India Publ. Agency.

Turener NC & Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress* . John Wiley & Sons.

5. FLA 601 ADVANCES IN BREEDING OF FLOWER CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of flower crops with special emphasis on crops grown in India.

Theory

UNIT I

Origin and evolution of varieties, distribution, Genetic resources, genetic divergence, Plant introduction, selection and domestication, Inheritance of important characters, Genetic mechanisms associated with flower colour and flower size, doubleness, fragrance and post-harvest life, Plant Variety Protection Act.

UNIT II

Specific objectives of breeding in flower crops, Methods of breeding suited to seed and

vegetatively propagated flower crops, Introduction, selection, polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility-Incompatibility problems, *In Vtro* breeding.

UNIT III

Breeding for resistance to pests, diseases, nematodes and other biotic and abiotic stresses in flower crops.

UNIT IV

Specific breeding problems and achievements made in rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, gerbera, gladioli, orchids and anthurium.

UNIT V

Specific breeding problems and achievements made in aster, petunia, liliums, heliconia, bird of paradise, hibiscus and bougainvillea.

Practical

Description of crops and cultivars; Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies; Induction of mutants; Physical and chemical mutagens; Induction of polyploidy; Screening of plants for biotic and abiotic stresses and environmental pollution; *in-vitro* breeding in flower crops.

Suggested Readings

Arora JS. 2006. *Introductory Ornamental Horticulture* . Kalyani.

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture* . Vols. I-VI. Pointer Publ.

Choudhary RC.1993. *Introduction to Plant Breeding.* Oxford & IBH.

Singh BD.1990. *Plant Breeding* . Kalyani.

6. FLA 602 ADVANCES IN FLOWER PRODUCTION TECHNOLOGY 2+1

Objective

To keep abreast with latest developments and trends in production technology of flower crops.

Theory

UNIT I

Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Soil and Environment; Special characteristics and requirements; cut flower, loose flowers, dry flowers and floral oil trade.

UNIT II

Propagation and multiplication; IPR issues related to propagation of materials; Greenhouse management; Soil/media decontamination techniques; Microirrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO_2 on growth and flowering; regulation for quality flowers.

UNIT III

Flower forcing and year-round flowering through physiological interventions; Chemical regulation; Environmental manipulation; Harvest indices; Harvesting techniques; Post-harvest handling; Precooling, pulsing, packing, marketing; Export potential; Agri Export Zones.

UNIT IV

Crop specific practices – rose, anthurium, orchids, carnation, gladioli, gerbera, liliums, heliconia, bird of paradise, *Jasminum* sp., marigold, tuberose, crossandra.

UNIT V

Floral oil industry, floral concrete production, extraction methods, recent advances.

Practical

Varietal wealth in flower crops; Greenhouse management; Soil decontamination techniques; Microirrigation; Nutrition and fertigation. Special practices- Pinching, netting, disbudding, defoliation and chemical pruning; Photoperiodic and chemical induction of flowering; Assessing harvest indices; Post-harvest handling; Tissue analysis; Preparation of floral decoratives; Extraction of floral concrete and oils; case studies; visit

to commercial cut flower units.

Suggested Readings

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

Chadha KL & Choudhury B. 1992. *Ornamental Horticulture in India* .ICAR.

George S & Peter KV. 2008. *Plants in a Garden* . New India Publ. Agency.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices.*Agrobios.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India* . Allied Publ.

Reddy S, Janakiram B, Balaji T, Kulkarni. S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

7. FLA 603 ADVANCES IN PROTECTED AND PRECISION FLORICULTURE 1+1

Objective

Appraisal on the advances in protected and precision farming of flower crops.

Theory

UNIT I

Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance.

UNIT II

Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques.

UNIT III

Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, liliums, cut foliage; Harvest indices – harvesting, PH handling, marketing, export.

UNIT IV

Precision floriculture, Principles and concepts, Enabling technologies of precision farming, GPS, GIS, Remote sensing, sensors.

UNIT V

Variability management in precision farming, mapping, variable rate technology, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

Practical

Growing structures, basic considerations in establishment and operation of greenhouses, Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques, Crop regulation, special horticultural practices under protected cultivation, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture* . Vols. I-VI. Pointer Publ.
Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
Reddy S, Janakiram B, Balaji T, Kulkarni S, & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

8. FLA 604 ADVANCES IN LANDSCAPE ARCHITECTURE 1+2

Objective

To update knowledge on the recent trends in the field of landscape horticulture and developing practical skills.

Theory

UNIT I

Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types.

UNIT II

Expenses to model landscaping units of all category, Creativity and communication skills for landscape architect, Way of designing a commercial landscape project.

UNIT III

Assessing site and plants adaptability for different locations, Landscape engineering (Topographical) survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning).

UNIT IV

Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing.

UNIT V

Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget / Project cost estimating, Execution strategies, Assessing a successful design in site.

Practical

Commercial landscaping, Plant identification, Materials of garden design, Design making by different garden styles and types. Way of designing a commercial landscape project, visit to model ornamental nursery. Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning). Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing. Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget/Project cost estimating, Execution.

Suggested Readings

Bose TK, Maiti RG, Dhua RS & Das, P. 1999. *Floriculture and Landscaping.* Naya Prokash.
Nambisan KMP. 1992. *Design Elements of Landscape Gardening* . Oxford & IBH.

List of Journals & Magazines

- Acta Horticulture
- Haryana Journal of Horticulture Science
- Horticulture Reviews
- HortScience
- Indian Horticulture
- Indian Journal of Arid Horticulture
- Indian Journal of Horticulture
- Journal of American Society of Horticultural Sciences
- Journal of Applied Horticulture
- Journal of Horticultural Sciences
- Journal of Horticultural Sciences & Biotechnology
- Journal of Japanese Society for Horticulture Science
- Journal of Korean Society for Horticulture Science
- Scientia Horticulture
- South Indian Horticulture
- Floriculture Today
- Journal of Landscape architecture
- Journal of Ornamental Horticulture

Suggested Broad Topics for Master's and Doctoral Research (Pomology)

- Micro-propagation of fruit crops
- Application of genetic engineering in fruit crops
- Use of molecular markers in fruit crops
- Fruit crop improvement
- Crop selection for biotic and abiotic stresses
- Diagnostic and recommended integrated system in cultivation of
- fruit crops
- Precision farming in fruit crops
- Protected cultivation of fruit crops
- Root distribution studies in fruit crops
- Canopy management in fruit crops
- Organic fruit cultivation
- Post harvest management of fruit crops
- Value addition in fruit crops
- Rejuvenation of orchards
- Replant problems in perennial fruit crops
- Research on burning problems in horticulture crops like mango malformation, citrus decline, guava wilt, alternate bearing, etc.

Suggested Broad Topics for Master's and Doctoral Research (Floriculture)

- Micro-propagation of major flower crops
- Application of genetic engineering in flower crops
- Use of molecular markers in flower crops
- Flower crops improvement
- Crop selection for biotic and abiotic stresses
- Diagnostic and recommended integrated system in floriculture
- Precision farming in floriculture
- Protected cultivation of flower crops
- Post-harvest management of flower crops
- Nutritional and water requirements of flower crops

XIV PLANTATION CROPS AND SPICES

COURSE STRUCTURE - AT A GLANCE

CODE	COURSE TITLE	CREDITS
PSMA 501*	PRODUCTION TECHNOLOGY OF PLANTATION CROPS	2+1
PSMA 502*	PRODUCTION TECHNOLOGY OF SPICE CROPS	2+1
PSMA 503*	PRODUCTION TECHNOLOGY OF MEDICINAL AND AROMATIC CROPS	2+1
PSMA 504*	BREEDING OF PLANTATION CROPS AND SPICES	2+1
PSMA 505*	BREEDING OF MEDICINAL AND AROMATIC CROPS	2+1
PSMA 506	ORGANIC SPICE AND PLANTATION CROP PRODUCTION TECHNOLOGY	2+1
PSMA 507	UNDEREXPLOITED MEDICINAL AND AROMATIC CROPS	1+1
PSMA 591	MASTER'S SEMINAR	0+1
PSMA 599	MASTER'S RESEARCH	20
PSMA 601**	ADVANCES IN PRODUCTION TECHNOLOGY OF PLANTATION CROPS	2+1
PSMA 602**	ADVANCES IN PRODUCTION TECHNOLOGY OF SPICES	2+1
PSMA 603**	ADVANCES IN PRODUCTION TECHNOLOGY OF MEDICINAL AND AROMATIC CROPS	2+1
PSMA 604**	ADVANCES IN BREEDING OF PLANTATION CROPS AND SPICES	2+1
PSMA 605	ADVANCES IN BREEDING OF MEDICINAL AND AROMATIC CROPS	2+1
PSMA 606	BIOTECHNOLOGY IN PLANTATION CROPS AND SPICES	1+1
PSMA 607	ENVIRONMENTAL HORTICULTURE	2+1
PSMA 691	DOCTORAL SEMINAR I	0+1
PSMA 692	DOCTORAL SEMINAR II	0+1
PSMA 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Doctoral programme

1 . PSMA 501 RODUCTION TECHNOLOGY OF PLANTATION CROPS 2+1

Objective

To impart basic knowledge about the importance and production technology of plantation crops grown in India.

Theory

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers,

rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed

management, training and pruning, crop regulation, maturity indices, harvesting. Cost benefit analysis, organic farming, management of drought, precision farming.

Crops

UNIT I

Coffee and tea

UNIT II

Cashew and cocoa

UNIT III

Rubber, palmyrah and oil palm

UNIT IV

Coconut and arecanut

UNIT V

Wattle and betel vine

Practical

Description of botanical and varietal features, selection of mother palms and seedlings in coconut and arecanut, soil test crop response studies and

manuring practices, pruning and training, maturity standards, harvesting, Project preparation for establishing plantations, Visit to plantations.

Suggested Readings

Anonymous, 1985. *Rubber and its Cultivation* . The Rubber Board of India.

Chopra VL & Peter KV. 2005. *Handbook of Industrial Crops* . Panima.

Harler CR. 1963. *The Culture and Marketing of Tea* . Oxford Univ. Press.

Kurian A & Peter KV. 2007. *Commercial Crops Technology* . New India Publ. Agency.

Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. *Cashew* . CPCRI, Kasaragod.

Peter KV. 2002. *Plantation Crops* . National Book Trust.

Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops* Part I, II. New India Publ. Agency.

Rai PS & Vidyachandram B. 1981. *Review of Work Done on Cashew* . UAS, Research Series No.6, Bangalore.

Ranganathan V. 1979. *Hand Book of Tea Cultivation* . UPASI, Tea Res. Stn. Cinchona.

Srivastava HC, Vatsaya B & Menon KKG. 1986. *Plantation Crops –Opportunities and Constraints* . Oxford & IBH.

Thampan PK. 1981. *Hand Book of Coconut Palm* . Oxford & IBH.

2.PSMA 502 PRODUCTION TECHNOLOGY OF SPICE CROPS 2+1

Objective

To impart basic knowledge about the importance and production technology of spices grown in India.

Theory

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, sowing/planting times and methods, seed rate and se ed treatment, nutritional and irrigation requirements, intercropping, mixed cropping,intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed planting material and micro-propagation, precision farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of:

UNIT I

Black pepper, cardamom

UNIT II

Clove, cinnamon and nutmeg, allspice

UNIT III

Turmeric, ginger and garlic

UNIT IV

Coriander, fenugreek, cumin, fennel, ajowain, dill, celery

UNIT V

Tamarind, garcinia and vanilla

Practical

Identification of seeds and plants, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, cultural practices, harvesting, drying, storage, packaging and processing, value addition; short term experiments on spice
crops.

Suggested Readings

Agarwal S, Sastry EVD & Sharma RK. 2001. *Seed Spices: Production,Quality, Export* . Pointer Publ.

Arya PS. 2003. *Spice Crops of India* . Kalyani.

Bhattacharjee SK. 2000. *Hand Book of Aromatic Plants* . Pointer Publ.

Bose TK, Mitra SK, Farooqi SK & Sadhu MK (Eds.). 1999. *Tropical Horticulture* . Vol.I. Naya Prokash.

Chadha KL & Rethinam P. (Eds.). 1993. *Advances in Horticulture* . Vols. IX-X. *Plantation Crops and Spices* . Malhotra Publ. House.

Gupta S. (Ed.). *Hand Book of Spices and Packaging with Formulae* . Engineers India Research Institute, New Delhi.

Kumar NA, Khader P, Rangaswami & Irulappan I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants* . Oxford
& IBH.

Nybe EV, Miniraj N & Peter KV. 2007. *Spices* . New India Publ. Agency.

Parthasarthy VA, Kandiannan V & Srinivasan V. 2008. *Organic Spices* . New India Publ. Agency.

Peter KV. 2001. *Hand Book of Herbs and Spices* . Vols. I-III. Woodhead Publ. Co. UK and CRC USA

Pruthi JS. (Ed.). 1998. *Spices and Condiments* . National Book Trust

Pruthi JS. 2001. *Minor Spices and Condiments- Crop Management andPost Harvest Technology* . ICAR.
Purseglove JW, Brown EG, Green CL & Robbins SRJ. (Eds.). 1981. *Spices* . Vols. I, II. Longman.
Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops* . Agrobios.
Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices* . ICAR.
Tiwari RS & Agarwal A. 2004. *Production Technology of Spices* . International Book Distr. Co.
Varmudy V. 2001. *Marketing of Spices* . Daya Publ. House.

3. PSMA 503 PRODUCTION TECHNOLOGY FOR MEDICINAL AND AROMATIC CROPS 2+1

Objective

To impart comprehensive knowledge about the production technology of medicinal and aromatic crops.

Theory

UNIT I

Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production, Role of institutions and NGO's in production, GAP in medicinal crop production.

UNIT II

Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, *Dioscorea* sp., *Aloe vera* , *Phyllanthus amarus, Andrographis paniculata, Digitalis, Atropha.*

UNIT III

Production technology for Medicinal solanum, Isabgol, Poppy, Safed musli, *Stevia rebaudiana, Mucuna pruriens, Ocimum sp., Piper longum, Plumpago, Holestemma.*

UNIT IV

Post harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

UNIT V

Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

UNIT VI

Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry.

UNIT VII

Production technology for palmarosa, lemongrass, citronella, vetiver, sandal, acorus, jasmine, geranium, artemisia, mentha, ocimum, eucalyptus, rosemary,thyme, patchouli, lavender, marjoram, oreganum.

UNIT VIII

Post-harvest handling, Distillation methods, advanced methods, Solvent extraction process, steam distillation, Perfumes from non-traditional plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations.

UNIT IX

Institutional support and international promotion of essential oil and perfumery products

Practical

Botanical description, Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites, Project preparation for

commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units. Extraction of Essential oils, Project preparation for commercially important Aromatic crops, Visit to distillation and value addition units – Visit to CIMAP.

Suggested Readings

Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Aromatic Plants* . RRL, CSIR, Jammu.

Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants* . RRL, CSIR, Jammu.

Farooqi AA & Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops* . Orient Longman Publ.

Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops* . Natural Remedies Pvt. Ltd.

Hota D. 2007. *Bio Active Medicinal Plants* . Gene Tech Books.

Jain SK. 2000. *Medicinal Plants* . National Book Trust.

Khan IA & Khanum A. *Role of Bio Technology in Medicinal and Aromatic Plants* . Vol. IX. Vkaaz Publ.

Kurian A & Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Panda H. 2002. *Medicinal Plants Cultivation and their Uses* . Asia Pacific Business Press.

Prajapati SS, Paero H, Sharma AK & Kumar T. 2006. *A Hand book of Medicinal Plants* . Agro Bios.

Ramawat KG & Merillon JM. 2003. *BioTechnology-Secondary Metabolites* . Oxford & IBH.

Skaria P Baby, Samuel Mathew, Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. *Aomatic Plants* . New India Publ. Agency.

4.PSMA 504 BREEDING OF PLANTATION CROPS AND SPICES 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of plantation crops and spices.

Theory

Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bioinformatics, IPR issues, achievements and future thrusts.

Crops

UNIT I

Coffee and tea

UNIT II

Cashew and cocoa

UNIT III

Rubber, palmyrah and oil palm

UNIT IV

Coconut and arecanut

UNIT V
Black pepper and cardamom
UNIT VI: Ginger and turmeric
UNIT VII: Fenugreek, coriander, fennel, celery and ajwoain
UNIT VIII: Nutmeg, cinnamon, clove and allspice

Practical

Characterization and evaluation of germplasm accessions, Blossom biology, studies on pollen behaviour, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for biotic and abiotic stresses, haploid culture, protoplast culture and fusion- induction of somaclonal variation and screening the variants. Identification and familiarization of spices; floral biology anthesis; fruit set; selfing and crossing techniques; description of varieties. Salient features of improved varieties and cultivars from public and private sector, bioinformatics, visit to radiotracer laboratory, national institutes for plantation crops and plant genetic resource centers, genetic transformation in plantation crops for resistance to biotic stress/quality improvement etc.

Suggested Readings

Anonymous 1985. *Rubber and its Cultivation* . The Rubber Board of India.
Chadha KL & Rethinam P. (Eds.).1993. *Advances in Horticulture* . Vol. IX. *Plantation Crops and Spices* . Part-I. Malhotra Publ. House.
Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops.* Malhotra Publ. House.
Chadha KL. 1998 . *Advances in Horticulture* . Vol. IX. *Plantation and Spices Crops* . Malhotra Publishing House, New Delhi.
Chopra VL & Peter KV. *Handbook of Industrial Crops* . Haworth Press. Panama International Publishers, New Delhi (Indian Ed.).
Damodaran VK, Vilaschandran T &.Valsalakumari PK. 1979. *Research on Cashew in India* . KAU, Trichur.
Ferwerden FP & Wit F. (Ed.). 1969. *Outlines of Perennial Crop Breeding in the Tropics* . H. Veenman & Zonen.
Harver AE. 1962. *Modern Coffee Production* . Leonard Hoff.
Raj PS & Vidyachandra B. 1981. *Review of Work Done on Cashew* . UAS Research Series No.6, Bangalore.
Thampan PK 1981 . *Hand Book of Coconut Palm* . Oxford & IBH.

5. PSMA 505 BREEDING OF MEDICINAL AND AROMATIC CROPS 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of plantation crops and spices.

Theory

UNIT I

Plant bio-diversity, conservation of germplasm, IPR issues, Major objectives of breeding of Medicinal and Aromatic Crops, Scope for introduction; cytogenetic background of important Medicinal and Aromatic Crops; Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches.

UNIT II

Breeding for yield and quality improvement in medicinal plants, Breeding for high herbage yield, essential oil and quality components, secondary metabolites in medicinal

and aromatic crops; Genetics of active principles and assay techniques useful in evaluation of breeder's material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops.

UNIT III

Achievements and prospects in breeding of medicinal crops, *viz* . *Cassia angustifolia* , *Catharanthus roseus* , *Gloriosa superba* , *Coleus forskohlii* ,

Stevia, *Withania somnifera* , *Papaver somniferum* , *Plantago ovata* , *Dioscorea* sp.

UNIT IV

Prospects in breeding of medicinal crops, *viz.* *Chlorophytum* sp, *Rauvolfia serpentina* , *Aloe vera*, *Ocimum* sp , *Phyllanthus amarus*, *Solanum* sp .

UNIT V

Prospects in breeding of aromatic crops viz., Geranium, vettiver, Lemon grass, Palmarosa, citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint .

Practical

Description of Botanical features, Cataloguing of cultivars, varieties and species in medicinal and aromatic crops, Floral Biology, Selfing and crossing, Evaluation of hybrid progenies, Induction of economic mutants, High alkaloid and high essential oil mutants, evolution of mutants through physical and chemical mutagens, Introduction of polyploidy, Screening of plants for biotic and abiotic stress and environmental pollution, *in-vitro* breeding in medicinal and aromatic crops.

Suggested Readings

Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants* . RRL, CSIR, Jammu.

Chadha KL & Gupta R. 1995. *Advances in Horticulture* . Vol. XI. Malhotra Publ. House.

Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops.* Natural Remedies Pvt. Ltd.

Jain SK. 2000. *Medicinal Plants* . National Book Trust.

Julia F & Charters MC. 1997. *Major Medicinal Plants – Botany, Culturesand Uses* . Thomas Publ.

Kurian A & Asha Sankar, M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Prajapati ND, Paero Hit SS, Sharma AK, Kumar T. 2006. *A Hand book of Medicinal Plants* . Agro Bios (India).

Skaria P Babu. 2007. *Aromatic Plants* . New India Publ. Agency.

Thakur RS, Pauri HS & Hussain A. 1989. *Major Medicinal Plants of India*. CSIR.

6.PSMA 506 RGANIC SPICE AND PLANTATION CROP PRODUCTION TECHNOLOGY 2+1

Objective

To educate principles, concepts and production of organic farming in spice and plantation crops.

Theory

UNIT I

Importance, principles, perspective, concept and component of organic production of spice and plantation crops.

UNIT II

Organic production of spice crops and plantation crops, *viz.* pepper, cardamom, turmeric, ginger, cumin, vanilla, coconut, coffea, cocoa, tea, arecanut.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavvya, Biodynamics, preparation etc.; Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, waster management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

Dahama AK. 2005. *Organic Farming for Sustainable Agriculture* . 2 Ed. ndAgrobios.

Gehlot G. 2005. *Organic Farming: Standards, Accreditation, Certification and Inspection* . Agrobios.

Palaniappan SP & Annadorai K. 2003. *Organic Farming: Theory and Practice* . Scientific Publ.

Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops* . New India Publ. Agency.

Shivashankar K. 1997. *Food Security in Harmony with Nature* . 3 IFOAM- rd ASIA, Scientific Conference. 1-4 Dec., 1997, UAS, Bangalore.

7. PSMA 507 NDEREXPLOITED MEDICINAL AND AROMATIC CROPS 1+1

Objective

To facilitate understanding on the importance, conservation and cultivation of medicinal and aromatic crops.

Theory

UNIT I

Introduction, importance, present status and future prospects, origin, distribution, species, varieties, economic parts and their uses in different diseases, Biodiversity and conservation, RET (Rare, Endangered and Threatened) and MPCAs (Medicinal Plants Conservation Areas).

UNIT II

Underutilized species – importance, traditional usage, ISM, TCM, Functional foods.

UNIT III

Production technology of underutilized medicinal crops– *Morinda citrifolia, Caesalpinia sappan , Terminalia chebula, Strychnos nuxvomica, Solanum trilobatum,* Physalis, *Aegle marmelos, Alpinia* sp., *Anthocephalus kadamba, Costus.*

UNIT IV

Production technology of underutilized aromatic crops– *Curcuma aromatica, C. caesia, Coleus aromaticus, Ocimum kilimanjaricum, Bursera.*

UNIT V

National and international conservation network, IPR issues, Promotion of under utilized species, Processing and value addition, Marketing.

Practical

Case studies.

Suggested Readings

Atal CK & Kapur BM. 1982. Cultivation and Utilization of Aromatic Plants. RRL, CSIR, Jammu.

Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants* . RRL, CSIR, Jammu.

Chadha KL Gupta. R. 1995. *Advance in Horticulture.* Vol. XI. *Medicinal & Aromatic Plants.* Malhotra Publ. House.

CSIR. 1971. *The Wealth of India.* Vols. A-Z . CSIR.

Farooqui AA, Khan MM & Sreeramu BS. 1997. *Cultivation of Medicinal and Aromatic Crops in India.* Naya Prokash.

Guenther E. 1975. *The Essential Oils.* Robert K. Krieger Publ. Co.

Jain SK. 1979. *Medicinal Plants.* National Book Trust.

Kurian A & Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Peter KV. (Ed.). 2007-08. *Underexploited and Underutilized Horticultural Crops* . Vols.I-IV. New India Publ. Agency.

Sivarajan VV & Balachandran I. 1994. *Ayurvedic Drugs and their Plant Sources.* Oxford & IBH.

Ph.D. COURSES

1. PSMA 6 01 ADVANCES IN PRODUCTION TECHNOLOGY OF PLANTATION CROPS 2+ 1

Objective

To keep abreast with latest developments and trends in production technology of plantation crops.

Theory

Plantation crops – area and production, export potential - varietal wealth and appraisal on the crop improvement in plantation crops. Mass multiplication techniques, High density planting, systems of cultivation, multitier cropping, companion cropping, studies of on canopy and root management, photosynthetic efficiencies of crops at different tiers, Biotic and abiotic factors on growth and productivity, nutritional requirements, role of macro and micro nutrients, Nutrient deficiency symptoms, growth regulators, water requirement, fertigation, soil and moisture conservation practices, Drought management, permanent vegetation management, Basin management, training and pruning, maturity indices, harvesting, curing, processing and value addition, grading, packing and storage, role of commodity boards in plantation crop development, Production of plantation crops through GAP, GMP, HACCP.

Crops

UNIT I

Coffee and tea

UNIT II

Cashew and cocoa

UNIT III

Rubber, palmyrah and oil palm

UNIT IV

Coconut and arecanut

UNIT V

Wattle and betelvine

Practical

Description of botanical and varietal features-selection of mother palms and elite clones, Clonal fidelity testing, nursery techniques and propagation methods, High density planting, training and pruning practices, fertigation and foliar nutrition, shade regulation, maturity standards, harvesting, curing, processing and grading, project preparation for establishing new plantations, visit to plantation gardens, commodity boards and plantation based industries.

Suggested Readings

Anonymous 1985. *Rubber and its Cultivation* . The Rubber Board of India.

Grimwood BE. 1975. *Coconut Palm Products* . FAO.

Kurian A & Peter KV. 2007. *Commercial Crops Technology* . New India Publ. Agency.

Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. *Cashew* . CPCRI, Kasaragod.

Patel JS. 1938. *The Coconut – A Monograph* . Govt. Press, Madras.

Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2007. *Management of Horticultural Crops.* Parts I, II. New India Publ. Agency.

Rai PS & Vidyachandram B. 1981. *Review of Work Done on Cashew* . UAS Research Series No.6, Bangalore.

Ranganathan V. 1979. *Hand Book of Tea Cultivation* . UPASI, Tea Res. Stn. Cinchona.

Srivastava HC, Vatsaya B & Menon KKG. 1986. *Plantation Crops – Opportunities and Constraints* . Oxford & IBH.
Thampan PK. 1981. *Hand Book of Coconut Palm* . Oxford & IBH.

2. PSMA 602 DVANCES IN PRODUCTION TECHNOLOGY OF SPICES 2+1

Objective

To educate advances in production technology of spice crops.

Theory

Spices- current status on area and production, state, national and global scenario of spices, global trade, problems encountered in spices productivity, systems of cultivation, varieties, soil and climate, propagation techniques and nursery management, planting systems and methods, cropping pattern, permanent floor management concepts in mulching and weed management, canopy and root studies under different spice-based cropping systems, shade and basin management, INM practices, irrigation and fertigation techniques, chemical regulation of crop productivity, IPM, clean cultivation strategies, harvesting, Post-harvest and quality

management for value added spices, quality standards, GAP and GMP for spices production, quality control and certification. Protected cultivation of high value spice crops. Value addition and byproduct utilization. Pricision farming and organic farming in spice crops. Commodity Boards in spices development

UNIT I

Pepper and cardamom

UNIT II

Nutmeg, clove, cinnamon and allspice

UNIT III

Turmeric, ginger, garcinia, tamarind and garlic

UNIT IV

Coriander, fenugreek, fennel, cumin and vanilla

UNIT V: Paprika and important herbal spices

Practical

Description of botanical and varietal features-Clonal fidelity testing, nursery techniques and propagation methods, fertigation and foliar nutrition, maturity standards, harvesting, curing, processing and grading, project preparation for establishing new spice gardens, visit to spice gardens, commodity boards and spices based industries.

Suggested Readings

Chadha KL. 2001. *Hand Book of Horticulture* . ICAR
George CK. (Ed.). 1989. *Proceedings of First National Seminar on Seed Spices* . Spices Board, Ministry of Commerce, Govt. of India, Kochi.
Marsh AC, Moss MK & Murphy EW. 1977. *Composition of Food Spices and Herbs, Raw, Processed and Prepared* . Agric. Res. Serv. Hand Book 8-2. Washinton DC.
Parry JW. 1969. *Spices and Condiments* . Pitman.
Peter KV. 2001. *Hand Book of Herbs and Spices* . Vols. I-III. Woodhead Publ. Co., UK & CRC, USA.
Purseglove JW. 1968. *Tropical Crops – Dicotyledons* . Longman.
Purseglove JW, Brown EG, Green CL & Robbins SRJ. 1984. *Spices.* Vols. I, II. Longman.
Ridley HM. 1972. *Spices* . Mac Millan.
Rosengarten F Jr. 1969. *The Book of Spices* . Wynnewood; Livingston Publ. Co.
Ravindran PN. 2001. *Monograph on Black Pepper* . CRC Press.
Ravindran PN & Madhusoodanan KJ. 2002. *Cardamom, The Genus Elettaria.* Series -

Medicinal and Aromatic Plants - Industrial Profiles . Routledge, UK.
Agarwal S, Divkara Sastry EV & Sharma RK. 2001. Seed Spices, Production, Quality and Export. Pointer Publ.
Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops* . Agrobios.
Winton AL & Winton KB. 1931. The Structure and Composition of Food. John Wiley & Sons.
Yagna Narayan Ayer AK. 1960. *Cultivation of Cloves in India* . ICAR.
Nybe EV, Mini Raj N & Peter KV. 2007. *Spices* . New India Publ. Agency.
Varmudy V. 2001. *Marketing of Spices* . Daya Publ. House.

3. PSMA 603 ADVANCES IN PRODUCTION TECHNOLOGY OF MEDICINAL AND AROMATIC CROPS 2+1

Objective

To keep abreast with latest developments and trends in productiontechnology of medicinal and aromatic crops.

Theory

UNIT I

Genetic biodiversity of medicinal plants, Conservation networks, Global initiatives on medicinal plants conservation and development, World history on usage of medicinal plants, Preference to natural products, Advanced research in biomedicines, Nutraceuticals and natural drugs, American, European and Asian legislations on plant drugs, Intellectual Property Rights, Patents.

UNIT II

Indian traditional wisdom and Heritage- Indian herbal wealth, Documentations, Databases, Scientific validation, Production Problems of Medicinal and Aromatic plants, Export and import status. WTO scenario - Principles and guidelines for GAP, GCP and GMP in medicinal crops.

UNIT III

Climate, Soil and substrate culture, Improved varieties, Organic production, Nutrition and irrigation requirements, inter culture, mulching, Weed control, Maturity indices and Harvesting, Post-harvest handling, Drying, Processing, Grading, Packing and Storage, Quality standards in medicinal plants, Biotechnological approaches for advances in phytochemical extraction technologies, Separation of Bio-molecules, Distillation methods, Essential oil extraction and value addition in aromatic plants, Phytochemicals and drug development.

UNIT IV

Medicinal crops : *Coleus forskohlii,* Glory liliy , Senna, Periwinkle , *Stevia rebaudiana,* Aswagandha , Sarpagandha , *Aloe vera, Dioscorea* sp ,*Phyllanthus amarus, Andrographis paniculata,* Medicinal solanum , Isabgol , *Poppy, Digitalis* sp , *Commiphora* sp , *Ipecac, Henbane, Ocimum* sp ., *Centella, Bacopa, Saraca indica* and *Bael.*

UNIT V

Aromatic crops: Palmarosa, Lemongrass, citronella, vetiver, Geranium, Artemisia, Mentha, Ocimum, Eucalyptus, Rosemary, Thyme, patchouli.

Practical

Identification and documentation- propagation in medicinal crops, Maturity standards, Harvesting and Drying techniques, Processing and grading, Analysis of bio-molecules, Extraction of secondary metabolites, identification and characterization of - secondary metabolites, Essential oils, Visit to commercial medicinal plants field, Visit to GMP phytochemical extraction and value addition unit.

Suggested Readings

Dharamvir H. 2007. *Bioactive Medicinal Plants* . Gene Tech Books.
Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops* . Natural Remedies Pvt. Ltd.
Farooqi.AA & Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops.* Orient Longman Publ.

Jain SK. 2000. *Medicinal Plants* . National Book Trust.
Khan IA & Khanum A. 2001 *Role of Biotechnology in Medicinal and Aromatic Plants* . Vol. IX. Vikaaz Publ.
Panda H. 2002. *Medicinal Plants Cultivation and their Uses* . Asia Pacific Business Press.
Prajapati ND, Paero Hit SS, Sharma AK & Kumar T. 2006. *A Hand Book of Medicinal Plants* . Agro Bios.
Ramawat KG & Merillon JM. 2003. *BioTechnology – Secondary Metabolites* . Oxford & IBH.

4.PSMA 604 ADVANCES IN BREEDING OF PLANTATION CROPS 2+1

AND SPICES

Objective

To keep abreast with latest developments and trends in production technology of medicinal and aromatic crops.

Theory

Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility system, recent advances in crop improvement efforts, introduction and selection, chimeras, clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in improvement of selected spice and plantation crops.

Crops

UNIT I
Coffee and tea
UNIT II
Cashew and cocoa
UNIT III
Rubber, palmyrah and oil palm
UNIT IV
Coconut and arecanut
UNIT V
Pepper and cardamom
UNIT VI
Nutmeg, clove, cinnamon and allspice
UNIT VII
Turmeric, ginger, garcinia, tamarind and garlic
UNIT VIII
Coriander, fenugreek, fennel, cumin and vanilla

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination, survey and clonal selection, screening techniques for abiotic stresses, screening and rating for pest, disease and stress resistance in inbreds and hybrids, estimation of quality and processing characters for quality improvement, use of mutagenes and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding and *in vitro* breeding techniques.

Suggested Readings

Chadha KL. 1998. *Advances in Horticulture* . Vol. IX, X. *Plantation and Spices Crops* Malhotra Publ. House.

Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops* . Malhotra Publ. House.

Chadha KL. 2001. *Hand book of Horticulture* . ICAR.

Chopra VL & Peter KV. 2002. *Handbook of Industrial Crops* . Haworth Press, USA &. Panama International Publ. (Indian Ed.).

Damodaran VK, Vilaschandran T & Valsalakumari PK.1979. *Research on Cashew in India* . KAU, Trichur.

George CK. (Ed.). 1989. *Proceedings of First National Seminar on Seed Spices* . Spices Board, Ministry of Commerce, Govt. of India, Kochi.

Harver AE. 1962. *Modern Coffee Production* . Leonard Hoff (Book) Ltd. Purseglove JW. 1968. *Tropical Crops – Dictyledons* . Longman.

Purseglove JW, Brown EG, Green CL & Robbins SRJ. 1984. *Spices* . Vols. I, II. Longman.

Peter KV. 2001-04. *Handbook of Herbs and Spices* . Vols.I-III.Woodhead Publ. Co., UK & CRC, USA.

Raj PS & Vidyachandra B. 1981. *Review of Work Done on Cashew* . UAS Research Series No.6, Bangalore.

Ravindran PN. 2001. *Monograph on Black Pepper* . CRC Press.

Ravindran PN & Madhusoodanan KJ. 2002. *Cardamom, The Genus Elettaria* Series on *Medicinal and Aromatic Plants - Industrial Profiles*. Routledge, UK

Rosengarten F Jr. 1969. *The Book of Spices* . Wynnewood; Livingston Publ. Co.

Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops* . Agrobios.

5. PSMA 605 ADVANCES IN BREEDING OF MEDICINAL AND AROMATIC CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of medicinal and aromatic crops with special emphasis on tropical,subtropical and temperate crops grown in India.

Theory

UNIT I

Origin and evolution of varieties, distribution- Genetic resources, genetic divergence, Plant introduction, selection and domestication - Inheritance of important characters, Genetic mechanisms associated with alkaloids and secondary metabolites.

UNIT II

Methods of breeding suited to seed and vegetative propagated crops. Polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility. Breeding for resistance to pests, diseases, nematodes in medicinal and aromatic crops.

UNIT III

Specific breeding objectives in medicinal and aromatic crops, Genetic bio diversity, Breeding problems and improvements in Senna , Periwinkle , Aswagandha , Isabgol , Sarpagandha , Poppy , Glory lily , *Coleus, Mucuna and Ocimum,* Centella, Bacopa, Dioscorea, Solanum, Andrographis, *Aloe vera* , Phyllanthus, Eucalyptus, Bael, Cinchona.

UNIT IV

Specific breeding objectives in medicinal and aromatic crops, Genetic bio diversity,

Breeding problems and improvements in Henbane aromatic grasses, Geranium, Patchouli, Artemisia, Rosemary, Thyme, Sage, Marjoram, Fever few.

UNIT V

Biotechnological approaches for crop improvement of medicinal and aromatic crops.

Practical

Description of crops and cultivars, Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies, Induction of economic, colour mutants, Increased alkaloid content in medicinal crops, high essential oil content in aromatic plants, Physical and chemical mutagens, Induction of polyploidy, Screening of plants for biotic and abiotic stresses and environmental pollution, *in-vitro* breeding in flower crops, medicinal and aromatic crops.

Suggested Readings

Atal C & Kapoor V. 1992. *Cultivation and Utilization of Medicinal and Aromatic Crops* . CSIR.

Chadha KL & Gupta R. 1995. *Advances in Horticulture* . Vol.XI. Malhotra Publ. House.

Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops* . Natural Remedies Pvt. Ltd.

Handa SS & Kaul MK. 1982. *Cultivation and Utilization of Medicinal Plants* . NISC, CSIR.

Jain SK. 2000. *Medicinal Plants* . National Book Trust.

Julia F & Charters MC. 1997. *Major Medicinal Plants – Botany, Cultures and Uses* . Thomas Publ.

Prajapati ND, Purohit SS, Sharma AK & Kumar T. 2006. *A Hand book of Medicinal Plants* . Agro Bios.

Thakur RS, Pauri HS & Hussain A. 1989. *Major Medicinal Plants of India*. CSIR.

6. PSMA 606 BIOTECHNOLOGY IN PLANTATION CROPS AND SPICES 1 +1

Objective

To teach advances in biotechnology for improvement of plantation crops and spices.

Theory

Crops : Coconut, oil palm, coffee, tea, cocoa, pepper, cardamom, turmeric, ginger, vanilla

UNIT I

In vitro culture methods and molecular approaches for crop improvement in plantation crops and spices, production of haploids, disease elimination in horticultural crops, micro grafting; somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II

Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation of spices and plantation crops.

UNIT III

In vitro mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV

Quality improvement; improvement for biotic and abiotic stresses; transgenic plants.

UNIT V

Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

Practical

Establishment of axenic explants, callus initiation and multiplication; production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids, Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods; molecular characterization of transgenic plants.

Suggested Readings

Bajaj YPS. (Ed.). 1987. *Biotechnology in Agriculture and Forestry* . Springer.

Chadha KL, Ravindran PN & Sahijram L. (Eds.). 2000. *Biotechnology of Horticulture and Plantation Crops* . Malhotra Publ. House.

Debnath M. 2005. *Tools and Techniques of Biotechnology* . Pointer Publ.

Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation* . Chapman & Hall.

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Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer* . Orient & Longman (Universal Press).

Keshavachandran R, Nazim PA, Girija D. & Peter KV 2007. *Recent Trends in Biotechnology of Horticultural Crops* . New India Publ. Agency.

Panopoulas NJ. (Ed.). 1981. *Genetic Engineering in Plant Sciences* . Praeger Publ.

Parthasarathy VA., Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. *Biotechnology of Horticultural Crops* . Vols. I-III.

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Prasad S. 1999. *Impact of Plant Biotechnology on Horticulture* . 2 nd Ed. Agro Botanica.

Sharma R. 2000. *Plant Tissue Culture* . Campus Books, International.

Singh BD. 2001. Biotechnology. Kalyani.

Skoog F & Miller CO. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro.* Symp. Soc. Exp. Biol. 11: 118-131.

Vasil TK, Vasi M, While DNR & Bery HR. 1979 . *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture* . Plenum Press.

Williamson R. 1981-86. *Genetic Engineering* . Vols. I-V. Academic Press.

7.PSMA 607 ENVIRONMENTAL HORTICULTURE 2+1

Objective

To teach advances in environmental management of horticultural crops.

Theory

UNIT I

Environmental complex, interaction of ecological factors in horticultural crop production, interaction of physiographic factors in horticultural crop production. Geo-chemical and hydrological cycles and their impact on ecosystems.

UNIT II

Global warming- carbon trading role of green house gases, elevated CO2 and its impact

on productivity of horticultural systems. Habitat ecology, changes in habitats and its impact on horticultural production,Habitat analysis, conservation biology, domestication. Forest ecosystem and its evolution to a hort-ecosystem.

UNIT III

Phytogeography. changes in land use pattern and its impact on horticultural crop production. Natural resource management in hortisystems. Subsistence farming systems of the world, threat and challenges.

UNIT IV

Envoronmental pollution in horti systems, chemicals, fertilizers, etc. Waste management in processing industry, phytoremediation.Alternate farming systems, horticultural therapy Environmental policy& legislation in India, International treatise and Summit, Biodiversity Board, Act, etc.

Practical

Phyto-sociological analysis, assessment of plant associations in natural and domestic systems, productivity assessment of various ecosystems, analysis and assessment of various phytogeographic zones, assessment of land use changes and its impact on horticultural systems, assessment of biodiversity, pesticide residue analysis in horticultural produce.

Suggested Readings

Ashby M. 1973. *Introduction to Plant Ecology* . MacMillan Press.

CSIR. 1971. *The Wealth of India* . Vols. A-Z. CSIR.

Daubenmire RF. 1959. *Plants and Environment* . Wiley Eastern.

Fall. 2001 . *Tolerance of Landscape Plants to Recycle Water Irrigation* . UC and ANR Publ.

Mathew IP & Karikari SK. 1990 *Horticulture Principles and Practices* . MacMillan Intermediate Agricultural Series.

Prasad S & Kumar U. 2003. *Principles of Horticulture* . Agrobios.

Sasikumar B, Krishna Murthy B, Rama.J, Ravindran PN & Peter KV. (Eds.). 1999. *Biodiversity Conservation and Utilization of Spices, Medicinal and Aromatic Plants* . IISR, Calicut.

Singh PP. 2006. *Perspectives in Plant Ecology and Environmental Biology* . Scientific Publ.

List of Journals & Magazines

- Acta Horticulture
- Haryana Journal of Horticulture Science
- Horticulture Reviews
- HortScience
- Indian Horticulture
- Indian Journal of Arid Horticulture
- Indian Journal of Horticulture
- Indian Spice
- Journal of American Society of Horticultural Sciences
- Journal of Applied Horticulture
- Journal of Horticultural Sciences
- Journal of Horticultural Sciences & Biotechnology
- Journal of Japanese Society for Horticulture Science
- Journal of Korean Society for Horticulture Science
- Journal of Plantation Crops
- Journal of Spices and Aromatic Crops
- Scientia Horticulture

- South Indian Horticulture
- Spice India
- Journal of medicinal and aromatic plant sciences

Suggested Broad Topics for Master's and Doctoral Research

- Micro-propagation of plantation crops and spices
- Application of genetic engineering in plantation crops, spices, medicinal and aromatic crops
- Use of molecular markers in plantation crops, spices, medicinal and aromatic crops
- Plantation crops, spic es, medicinal and aromatic crop improvement
- Crop selection for biotic and abiotic stresses
- Diagnostic and recommended integrated system in cultivation of plantation crops, spices, medicinal and aromatic crops
- Precision farming in plantation crops, spices, medicinal and aromatic crops
- Root distribution studies in plantation crops, spices, medicinal and aromatic crops
- Organic production of plantation crops, spices, medicinal and aromatic crops
- Post harvest management of plantation crops, spices, medicinal and aromatic crops
- Value addition in plantation crops, spices, medicinal and aromatic crops
- Rejuvenation of plantations and spice garden
- Research on burning problems in plantation crops, spices, medicinal and aromatic crops like root wilt of coconut, yellowing of areacanut, foot rot of black pepper, katte disease of cardamom etc.

e **- Resources in Horticulture**

- Australian Society for Horticultural Science http://www.aushs.org.au/
- Agricultural & Processed Food Products Export Development Authority (APEDA) http://www.apeda.com/
- American Society for Horticultural Science http://www.ashs.org/
- Australian Society for Horticultural Science http://www.aushs.org.au/
- Central Food Technological Research Institute (CFTRI) http://www.cftri.com/
- Central Institute of Medicinal & Aromatic Plants (CIMAP) http://www.cimap.org/
- Central Institute of Post harvest Engineering and Technology http://www.icar.org.in/ciphet.html
- Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala http://cpcri.nic.in/
- Consultative Group on International Agricultural Research, CGIAR http://www.cgiar.org/
- Coffee Board, India http://indiacoffee.org/
- Department of Agriculture and Co-operation, India http://agricoop.nic.in/
- Department of Bio-technology, India http://dbtindia.nic.in
- Department of Scientific and Industrial Research India, http://dsir.nic.in/
- FAO http://www.fao.org/

- Global Agribusiness Information Network: http://www.fintrac.com/gain/:
- Indian Agricultural Research Institute (IARI) http://www.iari.res.in/
- Indian Council of Agricultural Research (ICAR) http://www.icar.org.in
- Indian Institute of Horticultural Research (IIHR) www.iihr.res.in
- Indian Institute of Spices Research (IISR), Calicut, Kerala http://www.iisr.org/
- Institute for Horticultural Development, Victoria, Australia http://www.nre.vic.gov.au/agvic/ih/
- Kerala Agricultural University www.kau.edu
- Iowa State University Department of Horticulture http://www.hort.iastate.edu/
- National Bureau of Plant Genetic Resources (NBPGR), India http://nbpgr.delhi.nic.in/
- National Horticulture Board (NHB), India http://hortibizindia.nic.in/
- National Institute of Agricultural Extension Management (MANAGE), India http://www.manage.gov.in/
- National Research Centre for Cashew (NRCC), India http://kar.nic.in/cashew/
- National Research Centre for Oil Palm (NRCOP), India http://www.ap.nic.in/nrcop
- North Carolina State University, Dept. of Horticulture http://www2.ncsu.edu/cals/hort_sci/
- Oregon State University, Dept. of Horticulture http://osu.orst.edu/dept/hort
- Rubber Board, India http://rubberboard.org.in/
- Spice Paprika web site http://www.paprika.deltav.hu/:
- Spices Board, India http://www.indianspices.com/
- Sri Lanka Agribisness on-line http://www.agro-lanka.org/
- Tea Board, India http://tea.nic.in/
- The Horticultural Taxonomy Group http://www.hortax.org.uk/
- The USDA Agricultural Research Service http://www.ars.usda.gov/
- University of Florida, Dept. of Environmental Horticulture http://hort.ifas.ufl.edu/
- US Environmental Protection Agency http://www.epa.gov/:
- USDA http://www.usda.gov/

XV PROCESSING TECHNOLOGY

COURSE STRUCTURE - AT A GLANCE

CODE	COURSE TITLE	CREDITS
* PRT 501	PROCESSING AND PRODUCT DIVERSIFICATION OF FRUITS	2+1
* PRT 502	PROCESSING AND PRODUCT DIVERSIFICATION OF VEGETABLES	2+1
* PRT 503	PROCESSING AND VALUE ADDITION OF PLANTATION CROPS & SPICES	2+1
* PRT 504	PROCESSING AND VALUE ADDITION OF MEDICINAL AND AROMATIC PLANTS	2+1
* PRT 505	SENSORY EVALUATION AND QUALITY CONTROL IN PROCESSING OF HORTICULTURAL PRODUCE	2+1
PRT 506	ENTREPRENEURSHIP DEVELOPMENT FOR HORTICULTURE BASED PROCESSING INDUSTRIES	2+1
PRT 507	PACKAGING OF FRESH AND PROCESSED HORTICULTURAL PRODUCE	1+1
PRT 591	SEMINAR	0+1
PRT 599	RESEARCH	20
**PRT 601	ADVANCES IN VALUE ADDITION OF FRUITS AND VEGETABLES	2+1
**PRT 602	ADVANCES IN VALUE ADDITION OF PLANTATION CROPS	2+1
**PRT 603	ADVANCES IN VALUE ADDITION OF SPICES	2+1
**PRT 604	ADVANCES IN VALUE ADDITION OF MEDICINAL AND AROMATIC PLANTS	2+1
PRT 605	HI-TECH METHODS IN STORAGE, TRANSPORTATION AND PACKAGING OF HORTICULTURAL PRODUCE	2+1
PRT 606	MICROBIAL SPOILAGE, PESTICIDE RESIDUES AND POST-HARVEST DISEASES / DISORDERS OF HORTICULTURAL PRODUCE	2+1
PRT 607	ADVANCES IN FERMENTATION TECHNOLOGY WITH REFERENCE TO FRUIT AND VEGETABLE PRESERVATION	2+1
PRT 608	TECHNOLOGY OF FOOD FLAVOURS	1+1
PRT 691	DOCTORAL SEMINAR I	1+0
PRT 692	DOCTORAL SEMINAR II	1+0
PRT 699	RESEARCH (THESIS)	45

*Compulsory Courses for Master's programme; ** Compulsory Courses for Doctoral Programme

1. PRT 501 PROCESSING AND PRODUCT DIVERSIFICATION 2+1 OF FRUITS

Objective

To facilitate deeper understanding on the principles and practices of post harvest technology and diversification products in fruit crops.

Theory

UNIT I

Introduction to post harvest technology of fruits- pre harvest factors affecting quality and shelf life of fruits. Harvest indices, harvesting methods, harvesting practices for specific market requirements.

UNIT II

Physiology and biochemistry of fruit ripening; Physical and chemical changes during maturity and ripening; Ethylene action on ripening of fruits- ethylene management; Respiration of fruits and respiratory inhibitors.

UNIT III

Factors leading to post harvest losses, pre-cooling; Treatment prior to shipment viz, chlorination, waxing, chemical treatment. Role of biocontrol agents and natural plant products. Methods of storage, viz; ventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

UNIT IV

Importance of processing of fruits. Principles and methods of fruit preservation. Fruit juices, canning, unfermented beverages, fermented beverages, jam, jellies, marmalades, fruit juice concentrates, fruit powders.

UNIT V

Dried and dehydrated fruit products. Preserves, candies, glazed and crystallized fruits. Nutritionally enriched/ fortified fruit products., waste management and utilization. Natural fruit flavours, essence and aromatics, encapsulated fruit flavours. Subsidiary fruit products viz., cheese, halwa, toffee, leather Amchur, Papain etc.

UNIT –VI

Importance of fruit processing and nutrition; Maintenance of hygiene and sanitation of fruit processing industries; Quality control and regulation of fresh /processed fruits.

Practical

Determination of maturity of fruits by different methods- visual, physical, chemical, computational etc. Chemical analysis of fruits at different stages of maturity and ripening.

Estimation of respiration rate, ethylene release and quality characters of stored fruits. Preparation of various products, viz., juices, jellies, marmalades, preserves, candies, dried and dehydrated products, minor products viz., cheese, halwa, toffee, amchur, mango leather etc as per FPO regulations on domestic as well as commercial scales. Visit to cold storage and CA storage units, visit to fruit processing units, project preparation for small scale units and industrial fruit processing units. Evaluation of processed fruit products.

Suggested Rreadings

Bhutani, R.C. 2003. *Fruit and Vegetable Preservatio*n. Biotech Books. Chadha, K.L. & Pareek, O.P 1996. (Eds.). *Advances in Horticultur*e. Vol. IV. Malhotra Publ. House.

Haid ,N.F .& Salunkhe, S.K 1997. *Post Harvest Physiology and Handling of Fruits and Vegetable*s. Grenada Publ.

Lal,G.,. Siddappa G.S and. Tandon.G 1986. Preservation of Fruits and Vegetables. ICAR, New Delhi.

Mitra, S.K 1997. *Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruit*s. CABI.
Ryall, A.L. and Pentzer, W.T 1982. Handling, Transportation and Storage of Fruits and Vegetables. Vol.2, Fruits and Tree Nuts., AVI Pub. Co. Westport
Sudheer, K.P. & Indira ,V 2007. *Post Harvest Technology of Horticultural Crop*s. New India Publ. Agency.
Ranganna ,S 1997. *Hand Book of Analysis and Quality Control for Fruitand egetable Product*s. Tata McGraw-Hill. Verma, L.R. and Joshi, V.K 2000. *Post harvest Technology of Fruits and vegetables: Handling, Processing, Fermantation and Watse Management*.Indus Publ Co.

2.PRT502 PROCESSINGANDPRODUCTDIVERSIFICATIONOF VEGETABLES 2+1

Objective

To educate the principles and practices of processing and product diversification of vegetables.

Theory

UNIT I

Introduction to the processing of vegetables. Present status and future prospects of vegetable preservation industry in India.

UNIT II

Pre-harvest factors affecting quality and shelf life of vegetables. Spoilage of fresh and processed vegetable produce., biochemical changes and enzyme associated with spoilage., spoilage causing organisms, food poisoning and their control measures.

UNIT III

Principles and methods of vegetable processing. Primary and minimal processing . Processing equipment. Layout and establishment of vegetable processing industries. acquiring FPO license.

UNIT IV

Product diversification of vegetables. Major value added products. Modern methods of drying and dehydration of vegetables. Intermediate moisture foods. Utilization of byproducts of vegetable processing industries. Waste management in processing factory.

UNIT V

Development of vegetable wafers, flavouring of wafers and packing. Innovations in processing of pickles, sauces, ketchup, fermented vegetable products, vegetable extracts and vegetable powders. Vegetable flavours, aromatics and phyto - pigments.

UNIT VI

Grading of vegetables and characterization of value added products. Quality assurance and quality control. Food laws and standards- PFA, FPO,TQM, HACCP, nutrition labeling, Marketing Institutions etc.

Practical

Blanching of vegetables and its effect on enzymes. Chemical analysis for nutritive value of fresh and processed vegetables. Study of different types of spoilages in fresh as well as processed vegetable produce, identification of spoilage causing organisms, Study of biochemical changes and enzyme associated with spoilage. Preparation of various vegetable products viz., dried and dehydrated vegetables, wafers, pickles, sauces, ketchup, fermented vegetable products, vegetable powders, vegetable extracts etc as per food laws and standards. Laboratory examination of vegetable products.

Sensory evaluation of fresh and processed vegetables. Visit to processing units to study the layout, equipment, hygiene, sanitation and byproduct/ waste management.

Suggested Readings

Arthey, D & Dennis C. 1996. *Vegetable Processin*g. Blackie/Springer-Verlag.
Chadha, D.S. 2006. *The Prevention of Food Adulteration Ac*t. Confed. of Indian Industry.
FAO. 1997. *Fruit and Vegetable Processin*g. FAO.
Gisela, J. 1985. *Sensory Evaluation of Food – Theory and Practice*s. EllisHorwood.
Graham, H.D. 1980. *Safety of Food*s. AVI Publ. Co.
Hildegrade,H & Lawless, H.T. 1997. *Sensory Evaluation of Foo*d. CBS.
Luh, B.S and Woodroof ,J.G.1975. *Commercial Vegetable Processing*. AVI Publishing Co.
Mahindru, S.N. 2004. *Food Safety: Concepts and Realit*y. APH Publ. Corp
Ranganna ,S. 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Product*s. 2nd Ed. Tata-McGraw Hill.
Shapiro, R. 1995. *Nutrition Labeling Handboo*k. Marcel Dekker.
Srivastava,R.P & Kumar, S. 2003. *Fruit and Vegetable Preservation: Principles and Practice*s. 3 rd Ed. International Book Distri. Co.
Tressler & Joslyn, M.A. 1971. *Fruit and Vegetable Juice ProcessingTechnology*. AVI Publ. Co.
Wills, R.H.H.,. Lee,T.H. Graham,D.,.McGlasson,W.B and. Hall,E.G .1984. *Postharvest: An Introduction to the Physiology and handling of Fruit and Vegetables.*, AVI Pub. Co. Westport.

3.PRT 503 PROCESSING AND VALUE ADDITION OF PLANTATION CROPS & SPICES 2+1

Objective

To facilitate deeper understanding on the principles and practices of processing and value addition of plantation crops and spices.

Theory

UNIT I

Importance of plantation crops and spices in the economy of state of nation. Commercial uses of spices and plantation crops. Trading of plantation crops, spices and products in domestic and export markets.

UNIT II

Processing and value addition of plantation crops, viz., Coffee, Tea, Cocoa, Cashewnut, Coconut, Oil Palm, Arecanut, Rubber, Palmyrah palm .

UNIT III

Processing and value addition of major spices, viz., Black Pepper, Cardamom, Ginger, Turmeric, Chilli and Paprika.

UNIT IV

Processing and value addition of (i) tree spices:- Clove, Nutmeg, Cinnamon, Allspice, Camboge.

(ii) Seed spices and minor spices:- coriander, cumin, fennel, fenugreek, curry leaf and vanilla.

UNIT V

Innovations in value addition of plantation crops: virgin coconut oil, desiccated coconut, spray dried coconut powder, preservation of coconut inflorescence sap etc. Utilization of arecanut spathe for diversified uses. Modern method of chocolate manufacture. Decaffeinated coffee, Green tea, Oolong tea, Organic tea etc. . Hi-tech processing for extraction of essential oils and oleoresins from spices. Encapsulated spice flavours, extruded spices, essences, drops, nutraceuticals, pigment and aromatics.

Practical

Identification of different products of plantation crops and spices. Familiarizing different grades of plantation crops, spices and their products. Preparation of refined coconut oil, preserving tender coconut water and vinegar. Production of clarified juice, syrup and wine from cashew apple. Fermentation of cocoa beans and production of chocolate. Extraction of spice oleoresins and essential oils. Preparation of dried and dehydrated products from spices. Preparation of white pepper. Preparation of spice powders and curry powders. Visit to processing units of plantation crops and spices. Quality control of spices and plantation products.

Suggested Readings

Bavappa,K.V.A., Nair, M.K., Premkumar,T. 1982. *The Arecanut Palm Monograph serties*. CPCRI, Kasaragod.

Chadha KL et al. (Eds.). 1993-95. *Advances in Horticultur*e. Vol. IX *Plantation Crops and Spice*s. Malhotra Publishing House, NewDelhi.

Coreley,R.H.V., Harden,J.J., Wood,H.J. 1976. *Oil Palm Research and Development*. Crop Science-I. Longman, New York.

Mandal, RC. 1997. *Cashew: Production and Processing Technology*. Agro.Bot.

Masada ,Y.1986. *Analysis of Essential Oil by Gas Chromatograph and Mass Spectrometr*y. John Wiley & Sons.

Peter, K.V. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co., UK & CRC, USA.

Pruthi,J.S. 1993. *Major Spices of India. Crop Management and Post Harvest Technology*. ICAR, new Delhi.

Thampan, P.K. 1984. *Handbook on Coconut Palm*. Oxford and IBH Pub. Co. Nw Delhi.

4.PRT504 PROCESSING AND VALUE ADDITION OF MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To educate the principles and practices of processing and value addition of medicinal and aromatic crops.

Theory

UNIT I

Introduction and scope of medicinal and aromatic crops. Importance of medicinal and aromatic crops in modern medicine, ayurveda and indigenous system of medicine. Prospects of processing and value addition of medicinal and aromatic crops for utilization in the pharmaceutical, nutraceutical, flavour and perfumery industries.

UNIT II

Processing and value addition of medicinal plants, viz., Catharanthus,, Dioscorea, Solanum, Datura, Rauvolfia, Acorus, Digitalis, Ephedra, , Opium Poppy, Cannabis, Neem, Kaempferia, Plumbago, Alpinia, Adhatoda , Isabgol, Liquorice, Aloe, Safed musli, Sapan wood, Withania, Gloriosa, Stevia, Coleus.

UNIT III

Processing and value addition of aromatic plants, viz., - Lemon grass, Palmarosa, Vetiver, mint, Rose, tube rose, Rosemary, Eucalyptus, Sandalwood, Geranium, Jasmine, Patchouli, Lavender, Tulsi, Davana, Citronella etc.

UNIT IV

Extraction and analysis of active principles using TLC,GC, HPLC,Hydro-distillation, solvent extraction, enfleurage. Utilization of active principles of medicinal plants in the pharma sector. Study of aroma compounds of aromatic plants and their utilization in the perfumery industries. Nano-processing technology in medicinal and aromatic plants.

Practical

Harvesting of medicinal and aromatic plants. Primary processing, drying and storage. Secondary processing for extraction of active principles from medicinal plants and extraction of oils/ oleoresins from aromatic plants. Identification of active compounds of medicinal plants/ odouriferous compounds of aromatic plants by using TLC, GC, GC-MS, HPLC and other hi-tech equipment. Physico-chemical and sensory evaluation of oils, oleoresins and other extracts. Developing different value added products from medicinal and aromatic plants.

Suggested Readings

Chadha,K.L. and Gupta. R. 1995. *Advance in Horticulture* Vol. 11 Medicinal & Aromatic plants.Malhotra Pub. House, New Delhi.Handa,S.S. and M.K. Kabul. 1996. *Supplement to Cultivation and Utilization of Medicinal Plants* RRL (CSIR) Jammu- Tawi.

Kirthikar,K.R. and Basu,B.D.1993. *Indian Medicinal Plants*, Vol. 1-4. Lalit Mohan Basu, Allahabad.

Kurian, A .and Sankar, M.A.2007. *Medicinal Plants*. New India Publishing Agency, New Delhi.

Sudeer, K.P. and Indira,V.2008. *Post –Harvest Technology of Horticultural crops, Horticulture Science Series*. New India Publ. Agency.

5.PRT 505 SENSORY EVALUATION AND QUALITY CONTROL IN PROCESSING OF HORTICULTURAL PRODUCE 2+1

Objective

To educate the principles and concepts of sensory evaluation and quality control of horticultural produce.

Theory

UNIT I

Importance and methods of sensory analysis . Selection of panel and training requirements for a sensory evaluation laboratory.

UNIT II

Analysis for various sensory characters . Appearance, taste, smell, colour, texture and flavour.

Role of human senses:

1) Eye/Sight 2) Ear/Hearing 3) Skin/Feeling/Touch 4) Taste Buds/Taste
5) Olfactory Epithelium/Smell

UNIT III

Types of subjective tests:

1) ***Descriminative tests***-
a) Paired comparison test b) Triangle test c) Duo-trio test d) Threshold test

2) ***Descriptive tests***-
a) Ranking test b) Scoring test

3) ***Acceptance – Preference test***

UNIT IV

Role of sensory evaluation in product optimization. Sensory analysis for consumer evaluation. Designing of experiments. Interpretation of results.

UNIT V

Food laws and Quality control. Prevention of Food Adulteration (PFA), Fruit Products Order (FPO), International Standards Organization(ISO) accreditation. Eurep GAP Certification, SQF 1000, SQF 2000. HACCP, other standards and their importance in Quality Control. Good Agricultural Practices(GAP). Good Manufacturing Practices(GMP). Good Laboratory Practices(GLP). Organic Certification.

Practical

Procedure for sensory analysis. Identification of basic taste, odour, texture and colour. Determination of threshold activity. Hedonic testing. Testing of individual and overall quality by ranking. Selection of panel. Optimizing a product by sensory analysis. Hi-tech laboratory methods for quality control. Physico-chemical analysis of fresh material and finished products. Microbial load on samples. Quality estimation in processed material through FPO estimations. Fixation of ISO regulations and HACCP standards for export consignments. Estimation of nutritive value of fruits and vegetables: Carbohydrate, proteins, fat, vitamins, minerals etc. Analysis of processed products for fibre, flavonoids, vitamins, carotenoids, glucosinolates, fats , antioxidants etc.

Suggested Readings

Amerine, M.A. 1965. Methods in Sensory Analysis. AVI Publ: Co. West port.
Jellinek, G. 1985. Sensory Evaluation of Food. Ellis Horwood, England
O'Mahony,1985. Sensory Analysis of Foods : Statistical Methods. Marcel Dekker , Basal.
Piggot, J.R 1985.Sensory Analysis. Elsevier, Netherlands.
Ranganna, S. 1986. Manual of Analysis of Fruit and Vegetable Products.
Tata Mc Graw Hill Publishing Co. Ltd., New Delhi

6.PRT 506 ENTREPRENEURSHIP DEVELOPMENT FOR HORTICULTURE BASED PROCESSING INDUSTRIES 2+1

Objective

To impart latest knowledge and skills on entrepreneurship development for starting and running horticulture (processing) based industrial units.

Theory

UNIT I

Introduction to entrepreneurship development in horticulture. An overview of the food processing industry in Kerala and India. Exposure to commercially viable horticulture crops, raw materials and processed products for exploitation in the industrial sector.

UNI II

A review of trading of horticulture products in domestic and export markets for the past three decades. Future projections on the scope of trading through surveying and analysis of market intelligence data and reports.

UNIT III

Basic concepts on commencing small, medium and large industrial units. Availability and procurement of raw material. Acquiring land, water supply, electric connection and mobilizing manpower for the units. Architectural designs and civil works connected with establishment of units. Obtaining licenses (FPO, Commodity Boards Excise etc) and sanctions for the units. Subsidies entitled to food industries from State/ Central governments and other commodity boards etc.

UNIT IV

Industrial production of unfermented fruit beverages viz, RTC, nectar, cordial, squash, syrups etc. Bulk production and packaging of fruit juices, juice concentrates, fruit pulp, fruit flavours/aromatics etc. Commercial production of wafers from banana, potato, tapioca, sweet potato, tubers and other vegetables. Pilot production of essential oils,

oleoresins, super-erectile fluid exacts, encapsulated flavours, essences etc from spices/aromatic crops. Large scale manufacture of spicepowders, curry/masalapowders, dehydrated spices, freeze-dried spices, spices pastes etc. Manufacture of virgin coconut oil, spray-dried coconut milk powder, desiccated coconut, preserved (packed) tender coconut water, preserved coconut inflorescence rap etc.

UNIT V

Isolation and utilization of fine chemicals from spices, medicinal/aromatic plants in the industrial sector. Pharmaceutical, nutracentical, healthcare, drugs, flavour industries, aromatics etc. Examples; piperine, cineole, terpenyl acetate, gingerols, zingiberene, curcumin, capsaicins, capsanthin, pro- hydroxy citric acid, natural vanillin, eugenol, myristicin, cinnamaldehyde, geraniol etc.

UNIT VI

Management of human resources (Scientific, Technical, Skilled and un skilled personal). Risk factors and its management in horticulture in the industries. Obtaining export license for the units and keeping linkage with global markets. Studies on export/import policies and regulations. Accreditation of the units for international acceptance viz., ISO, HACCP, GMP, GLP, Eurepgap, organic certification etc.

Practical

Perusal of horticulture (processing) industries of Kerala and India. Success stories of enterprises/promising entrepreneurs in the sector. Managerial skills for entrepreneurs. Familiarizing harvested produce, graded raw materials and novel products from various horticulture crops. Economic and statistical analyzes of the domestic and export markets (back lock analyses and future projections). Application for land acquisition, water supply, electricity etc for the units. Procedure for obtaining sanctions from the local bodies, Government department and commodity boards. Applications for PFA, FPO, ISO certifications, HACCP, GMP, Organic certifications etc.

Human resources management, industrial rules, pay structure for qualified personnel, labour wages and rules, other amenities and benefits for technical, skilled and un skilled personnel. Mobilizing finance for the units from banks/other financial institutions. Applications for availing subsidies from State government, Ministry of Food Processing (GOI) and other commodity boards. Applications for obtaining quality accreditations, export license etc. Visits to small, medium and large industrial units for acquainting latest concepts/trends in product development and marketing. Visits to R&D units of NIIST, Trivandrum,CTCRI, Spices Board Coconut Board, Rubber Board, Coffee Board, UPASI, CPCRI, IISR, CFTRI, CDRL, For learning modern procedures in product development and quality control. Risk management and disaster management in agro-based industries.

Suggested and Readings

Acharya SS & Agarwal NL. 2004. *Agricultural Marketing in Indi*a. 4 th Ed. Oxford & IBH.

Girdharilal,G.S.,Siddappa,G.S and Tandon,G.L.1998.Presevation of fruits and vegetables.ICAR, New Delhi.

Hisrich, R.D. and Peters, M.P. 2005. Entrepreneurship. Tata Mc Graw- Hill Publishing Co. Ltd, New Delhi.

Kohls RL & Uhj JN. 2005. *Marketing of Agricultural Product*s. 9 th Ed. Prentice Hall.

Kotler P. 2002. *Marketing Management – Analysis, Planning, Implementation and Contro*l. Pearson Edu.

7.PRT 507 PACKAGING OF FRESH ANDPROCESSED HORTICULTURALPRODUCE 1+1

Objective

To acquaint and familiarise the process and techniques of packaging fresh as well as processed horticultural produce.

Theory

UNIT I

Introduction, history, function and scope of packaging industry in India. Packaging materials– paper based packaging, plastics, glass containers, metal packaging, natural materials etc.

UNIT II

Graphics and package design. Packaging machinery. Bottling and canning operations. Wrapping operations.

UNIT III

Bag manufacturing, filling and closing. Cartons, Corrugated Fibre Board boxes(CFB). Packing lines .

Packing needs of:

1) Heat processed foods 2) Fruit juice 3) Frozen foods 4) Freeze-dried Foods 5) Powders 6) Instant Foods etc.

UNIT IV

Primary, secondary and tertiary levels of packaging. Controlled Atmosphere packaging. Gas filling in packing. Vacuum packing and sealing. Hermetic sealing. Palletization, Handling of packages, Package regulations etc.

UNIT V

Specifications and quality control of packaging materials. Bulk packaging. Future thrust and scope of packaging technology.

Practical

Demonstration of different packaging materials and packaging systems. Evaluation of different packaging materials for their transport worthiness. Ventilation requirement in packing materials with different fruits and vegetables. ERH studies of different types of foods. Studies on gas exchange in plastic films. Visits to supermarkets and food malls for familiarizing different types of packaging. Visits to packaging fabrication industries. Visits to hi-tech packaging industries for acquainting packing of cashew nuts, coffee, tea, curry powders, spices, chocolates, processed fruit/vegetable products.

Suggested Readings

Kader, A.A., Kasmire, F.R., Mitchell, F.D., Reid, M.S., Somner, N.F and Thomson, J.F.1985. Post harvest technology of horticultural crops. Agrl. And Natural Resources Pub. U.C. Davis, U.S.A.

Potter, N.1978. Food Science .AVI Pub.Co., Westport.

Sreevastava, R.P. and Sanjeevkumar.1994. Fruit and Vegitable Preservation- Principles and Practices. International Book Distributing Co. Lucknow.

Wills, R.H.H., Lee, T.H., Graham, D and Hall, E.G. 1984.Post harvest: An Introduction to the Physiology and Handling of Fruits and Vegetables, AVI Pub. Co., West port.

Ph.D COURSES

1.PRT 601 ADVANCES IN VALUE ADDITION OF FRUITS AND VEGETABLES 2+1

Objective

To teach advances in post harvest technology and value addition of fruits and vegetables.

Theory

UNITI

Importance of post harvest management and value addition of fruits and vegetables. An over view on the post harvest losses of fresh fruits and vegetables in India. Prospects for value addition and product development in fruits and vegetables.

UNIT II

Climacteric and non-climacteric fruits. Respiration and ripening, Ethylene metabolism, its biosynthesis and regulation, molecular biology of ripening. Changes in enzymes and texture of fruits. Studies on installation and physiology of CA and MA storage systems.

UNIT III

Latest technologies in processing and value addition of commercial fruits(Tropical, sub- tropical and temperate). Recent concepts in the processing of fruit juices, juice concentrates, fruit pulp, fermented and unfermented beverages, fruit flavour, aromatics and pigments. Development of new and innovative products in major, minor and under-exploited fruits with emphasis on export.

UNIT IV

Modern methods in processing and value addition of vegetables for the domestic and export markets. Innovations in dried and dehydrated vegetable products. Improved recipes of pickles, sauces, ketchup, vegetable extracts and powders for global trading. Vegetable flavours, essences, aromatics and pigments. Research and development efforts on product diversification in vegetables.

UNIT V

Irradiation technology, vapour heat technology and other advanced technologies in processing of fruits and vegetables. Active packaging, bulk packaging and hi-tech practices for long distance (Surface, sea, air) transport of fresh as well as processed fruits / vegetables.

Practical

Harvesting of fruits and vegetables for specific requirements. Studies on pre-harvest factors and their effects on quality. Effects on environmental, cultural and varietal factors on post harvest behaviour of fruits and vegetables. Physico-chemical studies on fruits and vegetables prior to harvesting and during post- harvest and ripening stages. Experiments on the role of ethylene in ripening. Physiological and anatomical changes associated with ripening. Practical exercises on developing improved products from fruits and vegetables. Visits to modern processing units and familiarization of unit operations. Visits to quarantine stations ,bulk packaging units of shipping and air transporting centres of fruits and vegetables products.

Suggested Readings

Pantastico, E.B (Ed) . 1975. Post- harvest physiology, handling and utilization of tropical and sub- tropical fruits and vegetables. AVI Pub. Co., Westport.

Ryall, A.L. and Pentzer, W.T. 1982. Handling, transportation and storage of fruits and vegetables . Vol 2, Fruits and Tree Nuts, AVI Pub. Co., Westport.

Salunke, D.K. and Desai, B.B. 1984. Post- harvest Biotechnology of Fruit . Vol 1, CRS Press, Boca Raton.
Sudheer, K.P. and Indira, V. 2007. Post- harvest Technology of Horticultural Crops. New India Publ. Agency.
Wills, R.H.H., Lee, T.H., Graham, D., Mc Glasson, W.B and Hall, E.G. 1984. Post-harvest : An introduction to the physiology and handling of fruits and vegetables and vegetables, AVI Publ. Co., Westport.

2.PRT 602 ADVANCES IN VALUE ADDITION OF PLANTATION CROPS 2+1

Objective

To keep abreast with the latest innovations in on – farm processing, value addition and product diversification of plantation crops.

Theory

UNIT I

Introduction to the processing and products of plantation crops. Significance of on – farm processing and the quality of finished products. A survey on the plantation industries of Kerala and India. Problems facing the plantation industrial sector. Perspectives and scope for improvement.

UNIT II

Current scinario on the market infrastructure. Market behavior of plantation products during the past three decades. Products facing stiff competition and means to revive their market potential. Consumer's preferences and requirements for products. Future perspectives in marketing.

UNIT III

Resent concepts in value addition and product diversification of plantation crops.

(i) Coconut- Potential and scope of processing fresh coconut. Processing for shelf stableproducts from coconut milk/ cream. Spray dried coconut milk powder defatted coconut powder desiccated coconut , virgin coconut oil. Preservation of tender coconut water. preservation of coconut inflorescence sap. Commercial production of toddy, jaggery, alcohol and vinegar. Latest methods in refining and de-odourizing of coconut oil. Solvent extraction of coconut oil. Coconut based dairy foods-coconut chips, coconut biscuits, Nata-de-coes, coconut jam, coconut burfi, coconut honey etc. Coconut shell products, carvings, novelties and charcoal. Coir manufacturer and coir industry in Kerala, geotextiles.

(ii) Oil palm-Pilot processing of oil palm adopted by Oil Palm India Ltd. – Need for small scale processing units – Processing Technology practiced by NRC Oil Palm Palode. Quality characteristics of palm oil in comparison with coconut oil.

UNIT-IV

(i) Areca nut – Tender nuts : scope for manufacture of diversified masticatory products. Utilization of by products like furfural and phenolics in industrial sector. Isolation and formulation of alkaloids, viz. arecoline, guvacine, arecolidine etc. for pharmaceutical uses. Diversifed uses of areca spathe for production of plates, cups, spoons and other novelties.

(ii) Cashew nut – Small scale processing (cottage industry) of cashew nut in India. Hi-tech processing, grading, roasted nuts, flavoured nuts and other value-added products. Import of cashew nuts for the processing sector. Trends and scope for exports of cashew nuts. Cashew apple: exploitation for production for unfermented beverages (juice, nectar, squash, syrup etc.) cashew apple pickle and fermented beverages (wine, alcohol, feni). Scope of production of byproducts, viz, CNSL, testa tannins.

UNIT-V

(i) Coca – Role of varieties and improved strains in quality of processed products. Improved methods of fermentation, drying and processing. Coca butter, coca powder and byproducts. Small scale production of chocolate. Pilot manufacturer of chocolate.

(ii) Coffee – Role of Arabica, Robusta and other types in quality of processed coffee. Innovations in manufacturer of cherry coffee and powder. Characteristics of parchment coffee and its powder. Comparison of plain coffee vs. blended coffee (chicory blended). Advantages of specialty coffee. Discussions on branded coffee viz., Decaffeinated coffee, Mysore Nuggets, Plantation A, Pea Berry, Extra Bold, Monsoonized Malabar, Washed Robusta, CXR Coffee etc.

(iii)Tea- Problems facing tea production and processing. Scope for mechanization in plucking tea leaves. Orthodox tea: innovation in processing for meeting demand in global markets. Modern manufacturer CTC method and the scope of trading CTC in domestic as well as export markets. Specialty tea grades: Organic tea, Green tea, Oolong tea and other popular grades of tea. Chemistry of tea processing.

UNIT VI

An overview of the natural rubbers industry in Kerala and India. Recent methods in preservation and processing of latex. Innovations in production of sheet rubbers and crepe rubbers. Studies on processing operations and machinery for Technically specified Rubber (TSR), Specialty Rubbers viz., Super processing rubbers, Constant Viscosity NR, Low Viscosity NR, Oil extended Natural Rubber (OENR), Graft Natural Rubber, Deproteinised Natural Rubber., Epoxidised Natural Rubber.

UNIT VII

Competition and challenges for trading of plantation products in the post WTO scenario. Scope for evolving new and innovative products in plantation crops. Role of NIIST, Coconut Board, rubber Board, Oil Palm India Ltd, CPCRI, Tea Board, UPASI, Coffee Board, CFTRI, Directorate of Cashew etc. on the up liftment of plantation processing sector.

Practical

Acquainting the role of crop varieties in preparation of various products. Visits to progressive farmer's plots for learning recent trends in on-farm processing. Processing of row materials of plantation crops in the Lab for preparation of novel products. Quality characterization of plantation products. Visits to the local and export markets for familiarizing the currently traded products and their grades. Visits to processing units and R and D divisions of NIIST, Oil Palm India Ltd. Coconut Board, Coffee Board, UPASI, CPCRI, CFTRI, CAMPCO, Nestle, AVT Natural Products, Kerala Solvent Extractions Ltd etc.

Suggested Readings

Alice, K. and Peter, K.V. 2007. *Plantation Crops*. New India Publishing agency.

Bavappa, K.V.A., Nair, M.K. and Premkumar.T 1982. *The Arecanut Palm.* CPCRI, Kasaragod.

Coreley, R.H.V., Harden, J.J and wood, H.J 1976. *Oil Palm Research and Development, Crop Science-I.* Longman ,New York.

Radhakrishna Pillai, 1980. *Hand book of Natural production in India*. Rubber Board Kottayam.

Shammugavelu, K.G and Madhava Rao, V.N. 1977. *Spices and Plantation Crops*. Popular Book Depot, Madras.

Thampan, P.K. 1984. *Hand book on Coconut palm*. Oxford and IBH publ.Co., New Delhi.

3. PRT 603 ADVANCES VALUE ADDITION OF SPICES 2+1

Objective

To keep pace with the latest developments and trends in on- farm processing, value addition and product diversification of spices.

Theory

UNIT I

Importance of on-farm processing, value addition and product diversification of spices. An over view of the spices based processing industries in Kerala and India. A statistical review of the production, trading, price behaviour and earnings by means of marketing of spices and its products for the past three decades. Prospects for value addition, development of innovative products and chances for newer export markets for spices.

UNIT II

Adoption of improved on- farm processing methods and selection of choice crop varieties on the quality of finished products. Cleaning and grading of harvested/ processed produce at farm level. Effects of pre- treatments viz., blanching, chemical treatments, better drying methods (solar, electric, LPG drying) , improved bleaching methods etc. on better physico- chemical qualities of products.

UNIT III

Latest technologies in processing, value addition and product development of major spices viz., black pepper, cardamom (small and large), ginger, turmeric, chillies. Recent concepts in the processing of dried / de- hydrated spices, brining of fresh spices, frozen / freeze-dried spices, extraction of essential oils, oleoresins, super critical fluid extracts, essences, spice drops, encapsulated flavours, spice powders / curry powders, instant spices, spice pastes, extruded spices etc.

UNIT IV

Modern methods in processing, value addition and product development of :

(1) Tree spices viz., cinnamon, clove, nutmeg, camboge (kudampuli), all spice, tamarind etc.

(2) Minor spices viz., vanilla, curry leaf, mango ginger, mint, herbal spices etc.

(3) Seed spices viz., coriander, cumin, fennel, fenugreek, celery, mustard, poppy seed

UNIT V

Quality up-gradation in spices and spice products. Production, processing and certification for Organic spices. Establishment of spices based processing units. Discussions on role of institutions like NIIST, IISR, Spices Board, CFTRI and Private/ NGO' s on value addition of spices. Acquiring Logo, Certificates and Licence for internal trading and exports. Research and Development efforts for product diversification of spices. Future thrusts on processing and value addition of spices.

Practical

Stages of harvesting of spices for preparing products viz., dehydrated spices, canning, freezing, freeze- drying, oils, oleoresins, ground spices, brining of spices and other products. Influence of varieties for developing green products, dried/ de-hydrated products, spice powders, extraction of active principles and other diversified products. Visits to progressive farms for exposure to newer methods in on- farm processing. Acquainting on- farm operations like, cleaning, better drying methods, blanching, bleaching, grading etc. Visits to wholesale markets and export zones for familiaring the export grades. Distillation of essential oils, extraction of oleoresins, dehydrated spices, brining of spices, spice powders, curry powders, other extracts and products. Preparation of white pepper, dry ginger, dry turmeric, dry chillies etc. Preparation of bleached products from spices. Isolation of active principles from spices, viz., piperine,

cineole, esters, curcumin, zigiberene, gingerol, capsaicins, vanillin, eugenol etc. Physico chemical analysis on estimating the quality aspects of various spices. Visits to hi- tech processing units for familiarizing the manufacture of different products. Visits to R and D units of NIIST, Spices Board, IISR, Cochin Spices, Synthite, AVT Natural Products, Kancor, Eastern Spices, CFTRI etc.

Suggested Readings

Agarwal S, Sastry EVD & Sharma RK. 2001. *Seed Spices: Production, Quality, Expor*t. Pointer Publ.

Arya PS. 2003. *Spice Crops of Indi*a. Kalyani.

Kumar NA, Khader P, Rangaswami & Irulappan I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plant*s. Oxford & IBH.

Nybe EV, Miniraj N & Peter KV. 2007. *Spice*s. New India Publ. Agency.

Parthasarthy VA, Kandiannan V & Srinivasan V. 2008. *Organic Spice*s. New India Publ. Agency.

Peter, K.V. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co., UK & CRC, USA.

Pruthi,J.S. 1993. *Major Spices of India. Crop Management and Post Harvest Technology*. ICAR, new Delhi.

Pruthi JS. (Ed.). 1998. *Spices and Condiment*s. National Book Trust

Pruthi JS. 2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technolog*y. ICAR.

Purseglove JW, Brown EG, Green CL & Robbins SRJ. (Eds.). 1981. *Spice*s. Vols. I, II. Longman.

Tiwari RS & Agarwal A. 2004. *Production Technology of Spice*s. International Book Distr. Co.

Varmudy V. 2001. *Marketing of Spice*s. Daya Publ. House.

4. PRT 604 ADVANCES IN VALUE ADDITION OF MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To teach advances in post harvest processing and extractions of active principles of economically important medicinal and aromatic plants.

Theory

UNIT I

Medicinal and aromatic plants of economic importance. Studies on plant parts and stage of harvesting for extracting active principles. Primary processing of harvested produce.

UNIT II

Post harvest handily of plant material, pre-processing of raw material for packaging and further extraction of active ingredients. Methods of extraction of secondary metabolites from medicinal plants viz., Surpagandha, periwinkle, steroid-bearing solanums, ashwagandha senna , kempferia, plumbago, holostemma, aloe, safed mush, gloriosa, stevia, Coleus etc.

UNIT III

Harvesting, handling and processing of different aromatic crops: Oil-bearing rose, Jasmine, tuberose, Mint, Scented Jeranium, Patchouli, davanna, Vetiver, Eucaliptus, Tulsi, Sandal wood etc.

UNIT IV

Procedures, machinery and equipments used for extraction of active principles. Principles and practices of different types of extraction - hydro -distillation, solvent

extraction, supercritical fluid extraction etc. Chromatographic characterization of active principles - TLC ,GC, HPLC, MS. Quality estimation of essential oils and other extracts. Studies on flavours and fragrances from aromatic crops- pomade, enfleurage, concrete, absolute, attars etc.

UNIT IV

Manufacture of drugs and pharmaceuticals from natural isolate medicinal plants. Nutraceuticals and other help care agents from medicinal plants. Diversified uses of metabolites in various systems of medicine viz,. Modern, Ayurveda, Sidha, Homeopathy and other indigenous systems.

UNIT VI

Commercial uses of essential oils, extract and other active principles from aromatic plants in perfumery industries, toilet soaps, deodorants, body sprays, aromatherapy etc.

Practicals

Familiarising and identifying different economic parts of medicinal and aromatic crops. Morphological and anatomical studies of plant organs yielding active principles. Primary processing of plant material for extraction. Detailed exercises on the procedure of extraction of metabolites from medicinal plants and essential oil/oleoresins from aromatic crops. Study of solvents and procedures used in extraction of concrete and absolute. Handling of Chromatographs viz., TLC, GC, HPLC, MS, LCMS for isolation and quantification of the fine chemicals present in the active principles. Physio-chemical characterization and senory evaluation of essential oils. Storage of secondary metabolites and essential oils. Visits to R and D units of NIISST, Pappanmcodue, Rajive Gandhi Centre for Biotechnology, J.N Tropical Botanic Gardens, Syntehtic Chemicals, Kancor, Kerala Drugs and Pharmaceuticals, Oushadhi etc.

Suggested Readings

Chadha, K.L (Ed). 1995, *Advances in Horticulture* Vol.II

Medicinal and Armoatic Plants, Malhotra Publ.House, New Delhi.

Handa, S.S and Kanul, M.K, 1996. *Supplement to cultivation and utilization of medicial plants*, RRL (CSIR), Jammu Tawi.

Kirdhikar, K.R and Basu, B.D.1993. *Indian Medicinal Plants*, Vol.1-4, Allahabad.

Kurian.A. and Sankar, M.A 2007. *Medicinal Plants*. New India Publishing Agency, New Delhi.

Masada.Y, 1986. *Analysis* o*f Essential Oil by Gas Chromatograph and Mass Spectrometry*. John Wiley & Sons.

Sadasivan,S. and Manickam, A.1996. *Biochemical Methods*. 2nd Ed. New Age International Pvt.Ltd, Bangalore and TNAU, Scientific Publishers (India), Jodhpur.

Warrier, P.K, Nambiar, V.P.K and Ramankutty.C 1993-1996. Indian *Medicianal Plants- A Compendium*. Vol.1-5, Orient Longman Ltd., New Delhi.

Weiss, E.A. 1996. *Essential Oil Crops. CAB International*, U.K.

WHO, 1998 *Quality Control Methods for Medicinal Plants, Materials*. WHO.

5.PRT 605 HI-TECH METHODS IN STORAGE, TRANSPORTATION AND PACKAGING OF HORTICULTURAL PRODUCE 2+1

Objective

To educate the hi-tech processing methods in storage, transportation and packaging of fresh and processed horticultural produce.

Theory

UNIT I

Importance of storage and transportation of horticultureal produce. Studies in various storage systems. Refrigeration, Cooling systems and methods. Storage considerations: temperature, humidity-atmospheric composition etc.

UNIT II

Effect of psychometric variables on perishable commodities. Measurement of psychometric variables. M.A and C.A storage systems. Discussions on pre-storage treatments. Methods of atmospheric modification.

UNIT III

Transportation of perishable and processed commodities. Short distance transport for neighbouring markets. Methods and devices of long distance surface transport. Precautions in transporting of perishable commodities.

UNIT IV

Special techniques be transporting of horticultural perishable through sea and air routes. Modern transportation systems. Future thrusts in storage and transportation of horticultural produce.

UNIT V

Types of packages and their importance. Packaging design and regulations for local and export markets. Specifications and quality control in packaging. Consumer packaging and bulk packaging. Problems in packaging. Packing house operations. Selection of appropriate packages. Perspectives of packaging industry in India.

Practical

Exercises on storage of fresh fruits and vegetables. Pre-treatment for enhancing storage life of perishables. Refrigerated, C.A and M.A storage systems. Post-harvest treatments for enhancing shelf life. Measurement of psychometric variables for perishable commodities. Visits to local markets for understanding different transportation systems. Visits to sea ports/air ports for acquainting transportation by ship/air.

Methods of atmospheric modification in storage of perishables and processes products.

Laboratory studies on different packing methods for perishable and processed products. Modern packing methods for fruit juices, RTS, nectars, squashes, syrups, cans etc. Special packing systems for frozen, freeze-dried and dehydrated products. Innovations in the packing of curry powders, spice powders, cashew nuts, chocolates tea and coffee. Modifications in vacuum packing, gas filling, hermetic sealing. Visits to hi-tech packaging units of Nestle, Cadbury, Spices/plantation based industries.

Suggested Readings

Kader.A.A., Kasmire, F.R., Mitchell, F.D,1985. *Post-harvest Technology of Horticultural Crops*. Agrl.and Natural Resources Pub.USA.

Potter.N.1978. *Food Science*. AVI Pub.Co. Westport.

Sreevastava, R.P. and Sanjeev Kumar. 1994. *Fruit and Vegetable Preservation-Principles and Practices*, Internatinal Book Distributing Co. Lucknow.

Wills, R.H.H., Lee, T.H., Graham. D., McGlasson, W.B and Hall, E.G. 1984. *Physiology and handling of Fruit and Vegetables.* AVI Pub.Co. Westport.

6.PRT 606 MICROBIAL SPOILAGE, PESTICIDE RESIDUES AND POST- HARVEST DISEASES / DISORDERS OF HORTICULTURAL PRODUCE 2+1

Objective

To educate the occurrence, extent of damage and contamination of fresh and processed horticulture products by microbial infections, pesticide residue problems and post harvest diseases / disorders .

Theory

UNIT I

Introduction to microbial spoilage of foods, perishable raw materials and processed products. Causes of pesticide residues in fruits, vegetables, spices etc. Extent of post-harvest diseases and disorders in fruits and vegetables.

UNIT II

Classification of foods by spoilage of micro- organisms.

(1) Stable or non- perishable : Dry foods

(2) Semi perishable : Potatoes, apple, garlic etc.

(3) Perishable foods : Fruits, vegetables, fish, meat etc.

Causes of food spoilage. Contamination of fruits, vegetables, spices during harvesting, marketing and storage. Microbial profile and microbial load of harvested material and products. Detection of spoilage. Factors influencing growth of spoilage micro-organisms. Chemical and enzymatic changes caused by micro- organisms. Modern methods of controlling microbial spoilage.

UNIT III

Significance of pesticide residues in harvested materials and processed/finished products. Use of pesticides for protection of crops from pests, diseases, nematodes etc. Hazards due to pesticide residues. Levels of pesticide residues within tolerance limits. Maximum Residue Limits(MRL). Analysis of pesticide residues in fruits, vegetables and spices. Estimation (Identification and Quantification) of pesticide residues. Levels of pesticide residues and their role in export of horticultural crops/products.

UNIT IV

Major diseases and disorders during post harvest stages of fruits and vegetables. Organisms / Factors causing post harvest diseases/disorders.

Extent of losses due to post harvest diseases/disorders. Control of diseases/disorders.

UNIT V

Recent methods in detection of microbial spoilage of horticultural crops. Laboratories for testing pesticide residues in India. Hi-tech methods in storage of harvested materials and control of diseases /disorders for trading produce in domestic and export markets.

Practical

[A] Isolation and identification of various micro- organisms causing spoilage of raw materials and finished products. Detection of microbes viz.,

(1) Fungi : Moulds, *Rhizopus, Alternaria, Fusarium*

(2) Bacteria : *Pseudomonas, Xanthomonas, Bacillus, Coryneforms, Sclerotinia, Penicillium, Botrytis, Clostridium botulinum etc.*

Detection of spoilage causing organisms by plate counts.

Control measures for microbial spoilage by laboratory experiments:

(1) Maintenance of anaerobic conditions (2) Use of low temperature

(3) Drying (4) Irradiation (5) Aseptic packaging

[B] Identification and Quantification of pesticide residues by :

(1) Spectro- photometric techniques (2) GLC (3) HPLC (4) GC- MS (5) ELISA etc.

[C] Detection of organisms / Factors causing post- harvest diseases / disorders of fruits and vegetables.
Strategies for post- harvest disease control :
(1) Prevention and eradication of field infections
(2) Heat treatment (3) Chemicals (4) Irradiation (5) Fungicides (6) Antibiotics

Suggested Readings

Agrios, G.N. 1997. Plant Pathology. Academic Press. New York.
AOAC. 2005. Official Methods of Analysis. 18th ed. Association of Official Analytical Chemists, Washington DC.
Codex Alimentarius Commission. 2002. Codex Alimentarius.Pesticide Residues in Food. Vol II. Joint FAO / WHO Food Standard Programme.
Eckert, J.W. and Ratnayake. 1983. Post- harvest physiology and crop preservation. Plenum. Plenum. New York.
Instrumental Methods for Pesticide Residue Analysis. 2003. Division of Agrochemicals, IARI, New Delhi.
Pursky, D., Fuchs, Y. and Yanko, U. 1983. Plant Diseases.
Sahota, P.P. and Khanna, P.K. 2007. Microbial food spoilage and food borne diseases. In, Food Laws and Standards, ICAR Short Course, held at Punjab Agricultural University, Ludhiana.

7.PRT 607 ADVANCES IN FERMENTATION TECHNOLOGY WITH REFERENCE TO FRUIT & VEGETABLE PRESERVATION 2+1

Objective

To facilitate deeper understanding of the latest concepts in fermentation technology with emphasis on fruit and vegetable preservation.

Theory

UNIT I

Introduction, history, importance and scope of fermentation. Roles of fermentation in preservations. Different types of fermentation. General methods of fermentation.

UNIT II

Detailed study on the micro-organisms (yeasts and bacteria) employed in commercial fermentation. Culturing and maintenance of bacterial and yeast. Potential strains of acetic acid bacteria, lactic acid bacteria and yeasts. Biochemical basis of alcoholic, acetic and lactic fermentation.

UNIT III

Fermentation for value addition and waste management, Infrastructure, equipment and machinery for fermentation. Detailed studies on wines from different varieties of grapes. Classification and characteristics of wines. Studies on cider, perry, etc. Fermented beverages from under exploited fruits and vegetables. Latest techniques in production of vinegar and lactic acid.

UNIT IV

Production of fermented beverages from fruits viz., pineapple, mango, banana, papaya, Indian gooseberry, cashew apple, oranges, sapota, mangosteen, rambutan, litchi etc. Production of fermented beverages from vegetables, viz., carrot, beet root, sweet potato, tomato, cabbage and selected major vegetables. Fermentation technology adopted in commercial breweries. Production of alcohol from fermented beverages.

UNITV

Quality characteristics of fermented products. Spoilage of fermented products. Biochemical changes affected by fermented products. Addition of flavours, aromatics

and other additives in fermented beverages. Exploitation of waste material from fruit and vegetable processing units (canning, RTS, juices, squashes, wafers etc.) for utilization in manufacture of fermented beverages.

UNIT VI

Nutritive value of fermented products. Effects of aging and methods of storage on the quality of fermented products. An overview of the grape wineries and feni production in India. Perspectives and future thrusts in fermentation of horticulture crops.

Practical

Isolation and culture of different strains of yeasts belongs to *Saccharomyces ellipsoides* and *S. carlsbergensis*. Isolation and culture of acetic acid bacteria and lactic acid bacteria. Preparation of fermented products from fruits viz. wine (from different grape varieties), cider, perry, feni and from various major as well as under-exploited fruits. Preparation of fermented products from vegetables, viz., carrot, beet root, knoll khol, turnip, sweet potato, cabbage, tomato and selected major/under-exploited vegetables. Acquainting latest techniques, equipment and machinery on fermentation process. Analysis of alcohol, acidity, TSS, sugars etc. in fermented products. Preparation of fortified wines and flavoured fermented beverages. Isolation and characterization of spoilage causing organisms/factors in fermented products.

Suggested Readings

Amerine et al. 1980. *Technology of wine making.* AVI Pub.Co,. Westport.

Potter,N.1978. *Food Science*.AVI Pub.Co. Westport.

Reed,G.1999. *Prescott and Dunn's Industrial Microbiology*.CBS Publishers and Distributors, New Delhi.

Vine, R.P.1981. *Commerical Wine Making* .AVI Pub.Co.Westport.

8.PRT 608 TECHNOLOGY OF FOOD FLAVOURS 1+1

Objective

To educate the recent concepts and findings in the technology of food flavours.

Theory

UNIT I

Importance of food flavours in processing of horticulture crops. Characterization of food flavours. Introduction to the chemistry of flavour compounds. Natural flavourings and artificial flavourings. Precursors of flavours. An overview of the flavour industry.

UNIT II

Flavours in fruits and vegetables. Pathways of Fruit Flavour Formation. Pathways of Vegetable Flavour Formation. Location of Flavour in Plant. Environmental effects on flavour development. Influence of maturity on flavour development. Effects of post-harvest storage conditions on flavour development. Fruit aroma and Vegetable aroma compounds.

UNIT III

Changes in food flavour after processing. Non- enzymatic browning. (1) Formation of flavour compounds viz., Carbonyls, Pyrazines, Pyrroles, Nitrogen Heterocyclics, Sulfur Heterocyclics, Flavours from Lipids. (2) Flavours formed via Fermentation viz., Esters, Acids, Carbonyls, Alcohols, Terpenes, Lactones etc.

UNIT IV

Flavouring Materials of Natural Origin. Sources of Natural Flavouring Materials. Herbs and Spices. Fruit Juices and Flavour. Flavour of Onion, Garlic and other Vegetables. Flavour of Vanilla, Cocoa, Coffee, Tea etc.

UNIT V

Synthetic Flavouring Materials. Imitation Flavourings Matching Natural Flavours. Classification of Flavourants by Molecular Structure. Sensory characters of Synthetics. Consumer Attitudes toward Synthetic Chemicals.

UNIT VI

Flavour Potentiators. Natural Occurring ones. Source of Commercial Potentiators – Monosodium Glutamate and Other Potentiators . Sensory properties of Potentiators (Taste, Aroma, Synergism etc).

UNIT VII

Application of Flavourings – Meat Products, Bakery Products, Snack Foods, Sugar and Chocolate Confectionery, Soft Drinks etc.

Practical

Isolation and identification of flavours in fruits and vegetables. Laboratory studies on the effects of Post- harvest storage conditions on Flavour Development. Detection of Odd Flavours in Raw materials and Processed products. Isolation and identification of flavours and aromatics from Herbs and Spices. Laboratory experiments on the application of Natural / Synthetic flavours in processed products viz., Juices, RTS, Nectar, Cordial, Squashes, Syrups, Preserves, Candies, Fermented products and Subsidiary products viz, Fruit butters, Toffee, Cheese, Halwa etc.

Suggested Readings

AOAC . 1997. Official Methods of Analyses. Association of Official Analytical Chemists. Washington D.C.

Ashwani, K.G., Rajinder, K.and Satwinder, S.M. 2007. Post harvest management and value addition. Daya Publishing House, New Delhi..

Athey, D. and Dennis, C. 1991. Vegetable Processing. Glasgow. Blackie.

Food Colours, Flavours and Additives. Technology Handbook. 2005. National Institute of Industrial Research, New Delhi.

Food Flavours : Technology Handbook. 2004. National Institute of Industrial Research, New Delhi.

Jellinck, G. 1985. Sensory Evaluation of Food. Ellis Horwood, England.

Rananna, S. 1977. Manual of Analysis of Fruit and Vegetable Products, Tata Mc Graw Hill Publishing Co., New Delhi.

XVI AGRICULTURAL STATISTICS

COURSE STRUCTURE - AT A GLANCE

SL.NO	CODE	COURSE TITLE	CREDIT
1. Major courses For M.Sc.			
1	STAT 551	MATHEMATICAL METHODS-1	3+0
2	STAT 552	MATHEMATICAL METHODS-2	2+0
3	STAT 560	PROBABILITY THEORY	2+0
4	STAT 561	STATISTICAL MEYHODS	2+1
5	STAT 562	STATISTICAL INFERENCE	2+1
6	STAT 563	MULTIVARIATE ANALYSIS	2+1
7	STAT 564	DESIGN OF EXPERIEMNTS	2+1
8	STAT 565	SAMPLING TECHNIQUES	2+1
9	STAT 566	STATISTICAL GENETICS	2+1
10	STAT 567	REGRESSION ANALYSIS	1+1
11	STAT 568	STATISTICAL COMPUTING	1+1
12	STAT 569	TIME SERIES ANALYSIS	1+1
13	STAT 570	ACTURIAL STATISTICS	2+0
14	STAT 571	BIOINFORMATICS	2+0
15	STAT 572	ECONOMETRICS	2+0
16	STAT 573	STATISTICAL QUALITY CONTROL	2+0
17	STAT 574	OPTIMAISATION TECHNIQUES	1+1
18	STAT 575	DEMOGRAPHY	2+0
19	STAT 576	STATISTICAL METHODS FOR LIFE SCIENCES	2+0
20	STAT 577	STATISTICAL ECOLOGY	2+0
21	STAT591	MASTER'S SEMINAR	0+1
22	STAT 599	MASTER'S RESEARCH	20
2. Service / Minor/ Supporting Courses on Agricultural Statistics			
23	STAT 500	APPLIED MULTIVARIATE ANALYSIS	1+1
24	STAT 501	MATHEMATICAL METHODS FOR APPLIED SCIENCES	3+0
25	STAT 502	NUMERICAL ANALYSIS	2+0
26	STAT 503	MATHEMATICAL FOUNDATIONS IN COMPUTER SCIENCE	3+0
27	STAT 504	DATA PROCESSING	1+1
28	STAT 505	OPERATION RESEARH	2+1
29	STAT 506	BIOSTATISTICS AND COMPUTER APPLICATIONS	2+1
30	STAT 507	COMPUTER APPLICATION FOR MANAGEMNT	2+1
31	STAT 508	COMPUTERS-FUNDMENTALS AND PROGRAMMING	2+1
32	STAT 509	INTRODUCTION TO NETWORKING AND INTERNET APPLICATIONS	1+1
33	STAT 510	DATABASE MANAGEMENT SYSTEMS	1+1
34	STAT 511	STATISTICALMETHODS FOR APPLIED SCIENCES	2+1
35	STAT 512	EXPERIMENTAL DESIGNS	2+1
36	STAT 513	SAMPLING TECHNIQUES	2+1
37	STAT 521	APPLIED REGRESSION ANALYSIS	2+1
38	STAT 531	DATA ANALYSIS USING STATISTICAL PACKAGES	2+1
39	STAT 532	APPLIED STATISTICAL GENETICS	2+1
40	STAT 533	APPLIED LINEAR PROGRAMMING	1+1

41	STAT 534	TIME SRIES AND QUALITY CONTROL	2+1
42	STAT 536	NON PARAMETRIC METHODS	2+0
3. Remedial/ supporting courses in Mathematics and Statistics for Agrl. Graduates admitted to M.Sc.			
	STAT 537	CALCULUS	2+0
	STAT 538	ANALYTICAL GEOMETRY	2+0
	STAT 539	MODERN ALGEBRA	1+0
	STAT 540	MATRIX ALGEBRA	2+0
	STAT 541	TRIGONOMETRY	1+0
	STAT 542	PROBABILITY THEORY	2+0
	STAT 543	MATHEMATICS	2+0
	STAT 544	BASIC STATISTICS	2+0
4. Supporting /Remedial courses for Non Agricultural graduates admitted for M.Sc.			
	SOILS 519	INTODUCTION TO SOIL SCIENCE	2+1
	AGRON 501	MODERN CONCEPTS IN CROP PRODUCTION	3+0
	AGECON 519	GENERAL ECONOMICS	2+0
	EXT 501	DEVELOPMENT PERSPECTIVE OF EXTENSION EDUCATIOM	1+1
	PFMA 501	PRODUCTION OF PLANTATION CROPS	1+1
	VSC 502	PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS	2+1
	FSC 505	PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS	2+1
	ENT 525	INTRODUCTORY AND ECONOMIC ENTOMOLOGY	1+1
	AGM 506	CROP WEATHER MODELS	1+2
	FN 515	FOOD AND NUTRITION	2+0
	GP 520	GENETICS	2+0
	VS 501	FUNDAMENTALS OF LIVESTOCK AND POULTRY PRODUCTION	2+1
	VS 502	DAIRY CATTLE PRODUCTION	2+0
	VS503	ANIMAL BREEDING	2+0
5. Non –Credit compulsory for Non –Agricultural Graduates in addition to the above.			
	PGS 507	CROP PRODUCTION: CONCEPTS AND PRACTICES	2+1

Minimum credit requirements for M.Sc. (Agricultural Statistics)

Subject	Credits
Major	25
Minor	09
Supporting	05
Seminar	01
Research	20
Total credits	60
Compulsory Non Credit Courses (i) General nature (ii) Deficiency courses	 06 14
Grand total	**80**

1. MAJOR COURSES FOR M.Sc.

1. STAT 551 MATHEMATICAL METHODS – I 3+0

Objective

This course lays the foundation of all other courses of Statistics /Agricultural Statistics discipline by preparing them to understand the importance of mathematical methods in research. The students would be exposed to the basic mathematical tools of real analysis, calculus, differential equations and numerical analysis. This would prepare them to study their main courses that involve knowledge of Mathematics.

Theory

UNIT I

Real Analysis: Convergence and divergence of infinite series, use of comparison tests - D'Alembert's Ratio - test, Cauchy's nth root test, Raabe's test, Kummer's test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes' transformation, multiple integrals.

UNIT II

Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series. Application of derivatives, L'hospital's rule. Integration of rational, irrational and trigonometric functions. Application of integration.

UNIT III

Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

UNIT IV

Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

Suggested Readings

Bartle RG. 1976. *Elements of Real Analysis*. John Wiley.
Chatterjee SK. 1970. *Mathematical Analysis*. Oxford & IBH.
Gibson GA. 1954. *Advanced Calculus*. Macmillan.
Henrice P. 1964. *Elements of Numerical Analysis*. John Wiley.
Hildebrand FB. 1956. *Introduction to Numerical Analysis*. Tata McGraw Hill.
Priestley HA. 1985. *Complex Analysis*. Clarenton Press.
Rudin W. 1985. *Principles of Mathematical Analysis*. McGraw Hill.
Sauer T. 2006. *Numerical Analysis With CD-Rom*. Addison Wesley.
Scarborough JB. 1976. *Numerical Mathematical Analysis*. Oxford & IBH.
Stewart J. 2007. *Calculus.* Thompson.
Thomas GB Jr. & Finney RL. 1996. Calculus. 9th Ed. Pearson Edu.

2. STAT 552 MATHEMATICAL METHODS – II 2+0

Objective

This is another course that supports all other courses in Statistics / Agricultural Statistics. The students would be exposed to the advances in Linear Algebra and Matrix theory. This would prepare them to study their main courses that involve knowledge of Linear Algebra and Matrix Algebra.

Theory

UNIT I

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt's orthogonalization, Galois field - Fermat's theorem and primitive elements. Linear transformations. Graph theory: Concepts and applications

UNIT II

Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, rank and inverse of matrices. Special matrices – idempotent, symmetric, orthogonal. Eigen values and eigen vectors. Spectral decomposition of matrices

UNIT III

Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker sum of matrices. Sub-matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix. Solutions of linear equations, Equations having many solutions.

UNIT IV

Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of matrices, Quadratic forms.

Suggested Readings

Aschbacher M. 2000. *Finite Group Theory*. Cambridge University Press.

Deo N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.

Gentle JE. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.

Graybill FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.

Hadley G. 1969. *Linear Algebra*. Addison Wesley.

Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.

Rao CR. 1965. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Robinson DJS. 1991. *A Course in Linear Algebra with Applications*. World Scientific.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Seber GAF. 2008. *A Matrix Handbook for Statisticians*. John Wiley.

3. STAT 560 PROBABILITY THEORY 2+0

Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics. The students are also exposed to law of large numbers and central limit theorem. The students also get introduced to stochastic processes.

Theory

UNIT I

Basic concepts of probability. Elements of measure theory: class of sets, field, sigma field, minimal sigma field, Borel sigma field in R, measure, probability measure. Axiomatic approach to probability. Properties of probability based on axiomatic definition. Addition and multiplication theorems. Conditional probability and independence of events. Bayes theorem.

UNIT II

Random variables: definition of random variable, discrete and continuous, functions of random variables. Probability mass function and Probability density function,

Distribution function and its properties. Notion of bivariate random variables, bivariate distribution function and its properties. Joint, marginal and conditional distributions. Independence of random variables. Mathematical expectation: Mathematical expectation of functions of a random variable. Raw and central moments and their relation, covariance, skewness and kurtosis. Addition and multiplication theorems of expectation. Definition of moment generating function, cumulating generating function.

UNIT III

Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Functions, which cannot be characteristic functions. Chebyshev, Markov, Cauchy-Schwartz, Jenson, Liapounov, holder's and Minkowsky's inequalities. Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutsky's theorem. Borel –Cantelli lemma and Borel 0-1 law.

UNIT IV

Laws of large numbers: WLLN, Bernoulli and Kintchin's WLLN. Kolmogorov inequality, Kolmogorov's SLLNs. Central Limit theorems: Demoviere- Laplace CLT, Lindberg – Levy CLT, Liapounov CLT, Statement of Lindeberg-Feller CLT and simple applications. Definition of quantiles and statement of asymptotic distribution of sample quantiles.

UNIT V

Classification of Stochastic Processes, Examples. Markov Chain and classification of states of Markov Chain.

Suggested Readings

Ash RB. 2000. *Probability and Measure Theory*. 2nd Ed. Academic Press.

Billingsley P. 1986. *Probability and Measure*. 2nd Ed. John Wiley.

Capinski M & Zastawniah. 2001. *Probability Through Problems*. Springer.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Feller W. 1972. *An Introduction to Probability Theory and its Applications*. Vols. I., II. John Wiley.

Loeve M. 1978. *Probability Theory*. 4th Ed. Springer.

Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.

Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

4. STAT 561 /STATISTICAL METHODS 2+1

Objective

This course lays the foundation of probability distributions and sampling distributions and their application which forms the basis of Statistical Inference. Together with probability theory, this course is fundamental to the discipline of Statistics. The students are also exposed to correlation and regression, and order statistics and their distributions. Categorical data analysis is also covered in this course.

Theory

UNIT I

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric, uniform, multinomial ~ Properties of these distributions and real life examples. Continuous probability distributions ~ rectangular, exponential, Cauchy, normal, gamma, beta of two kinds, Weibull, lognormal, logistic, Pareto. Properties of these distributions. Probability distributions of functions of random variables.

UNIT II

Concepts of compound, truncated and mixture distributions (definitions and examples). Pearsonian curves and its various types. Sampling distributions of sample mean and sample variance from Normal population, central and non–central chi-Square, *t* and *F* distributions, their properties and inter relationships.

UNIT III

Concepts of random vectors, moments and their distributions. Bivariate Normal distribution - marginal and conditional distributions. Distribution of quadratic forms. Cochran theorem. Correlation, rank correlation, correlation ratio and intra-class correlation.

Practical

Fitting of discrete distributions and test for goodness of fit; Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution; Computation of moments and their distributions. Bivariate Normal distribution, Correlation, rank correlation, correlation ratio and intra-class correlation.

Suggested Readings

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.

Arnold BC, Balakrishnan N & Nagaraja HN. 1992. *A First Course in Order Statistics*. John Wiley.

David HA & Nagaraja HN. 2003. *Order Statistics*. 3rd Ed. John Wiley.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Huber PJ. 1981. *Robust Statistics*. John Wiley.

Johnson NL, Kotz S & Balakrishnan N. 2000. *Continuous Univariate Distributions*. John Wiley.

Johnson NL, Kotz S & Balakrishnan N. 2000. *Discrete Univariate Distributions*. John Wiley.

Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.

Rao CR. 1965. *Linear Statistical Inference and its Applications*. John Wiley.

Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

5. STAT 562 STATISTICAL INFERENCE 2+1

Objective

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures and elements of decision theory.

Theory

UNIT I

Concepts of point estimation: MSE, unbiasedness, consistency, efficiency and sufficiency. Statement of Neyman's Factorization theorem with applications. MVUE, Rao-Blackwell theorem, completeness, Lehmann- Scheffe theorem. Fisher information, Cramer-Rao lower bound and its applications.

UNIT II

Moments, minimum chi-square, least square and maximum likelihood methods of estimation and statements of their properties. Interval estimation-Confidence level, CI using pivots and shortest length CI. CI for the parameters of Normal, Exponential, Binomial and Poisson distributions.

UNIT III

Fundamental notions of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized and nonrandomized tests, level of significance, power function, most powerful tests: Neyman-Pearson fundamental lemma, MLR families and UMP tests for one parameter exponential families. Concepts of consistency, unbiasedness and invariance of tests. Likelihood Ratio tests, statement of asymptotic properties of LR tests with applications (including homogeneity of means and variances).Relation between confidence interval estimation and testing of hypothesis.

UNIT IV

Notions of sequential *vs* fixed sample size techniques. Wald's SPRT for testing simple null hypothesis *vs* simple alternative. Termination property of SPRT, SPRT for Binomial, Poisson, Normal and Exponential distributions. Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, conjugate families, Bayes and Minimax decision functions with applications to estimation with quadratic loss.

Practical

Methods of estimation - Maximum Likelihood, Minimum Chi-^{2} and Moments; Confidence Interval Estimation; MP and UMP tests; Large Sample tests; Sequential Probability Ratio Test; Decision functions.

Suggested Readings

Box GEP & Tiao GC. 1992. *Bayesian Inference in Statistical Analysis*. John Wiley.

Casela G & Berger RL. 2001. *Statistical Inference*. Duxbury Thompson Learning.

Christensen R. 1990. *Log Linear Models*. Springer.

Conover WJ. 1980. *Practical Nonparametric Statistics*. John Wiley.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Gibbons JD. 1985. *Non Parametric Statistical Inference*. 2nd Ed. Marcel Dekker.

Kiefer JC. 1987. *Introduction to Statistical Inference*. Springer.

Lehmann EL. 1986. *Testing Statistical Hypotheses*. John Wiley.

Lehmann EL. 1986. *Theory of Point Estimation*. John Wiley.

Randles RH & Wolfe DS. 1979. *Introduction to the Theory of Nonparametric Statistics*. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Rohatgi VK & Saleh AK. Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

Rohtagi VK. 1984. *Statistical Inference*. John Wiley

Sidney S & Castellan NJ Jr. 1988. *Non Parametric Statistical Methods for Behavioral Sciences*. McGraw Hill.

Wald A. 2004. *Sequential Analysis*. Dover Publ.

6. STAT 563 MULTIVARIATE ANALYSIS 2+1

Objective

This course lays the foundation of Multivariate data analysis. Most of the data sets in agricultural sciences are multivariate in nature. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods would help the students in having a better understanding of agricultural research data, its presentation and analysis.

Theory

UNIT I

Concept of random vector, its expectation and Variance-Covariance matrix. Marginal and joint distributions. Conditional distributions and Independence of random vectors. Multinomial distribution. Multivariate Normal distribution, marginal and conditional distributions. Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersion matrix. Tests of hypothesis about mean vector.

UNIT II

Wishart distribution and its simple properties. Hotelling's T^2 and Mahalanobis D^2 statistics. Null distribution of Hotelling's T^2. Rao's U statistics and its distribution.Wilks' λ criterion and statement of its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between k (=2) multivariate normal populations based on LDF and Mahalanobis D^2.

UNIT III

Principal Component Analysis, factor analysis (simple and multi factor models). Canonical variables and canonical correlations. Cluster analysis, similarities and dissimilarities, Hierarchical clustering. Single and Complete linkage methods.

Practical

Maximum likelihood estimates of mean-vector and dispersion matrix; Testing of hypothesis on mean vectors of multivariate normal populations; Cluster analysis, Discriminant function, Canonical correlation, Principal component analysis, Factor analysis; Multivariate analysis of variance and covariance.

Suggested Readings

Anderson TW. 1984. *An Introduction to Multivariate Statistical Analysis*. 2nd Ed. John Wiley.

Arnold SF. 1981. *The Theory of Linear Models and Multivariate Analysis*. John Wiley.

Giri NC. 1977. *Multivariate Statistical Inference*. Academic Press.

Johnson RA & Wichern DW. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.

Kshirsagar AM. 1972. *Multivariate Analysis*. Marcel Dekker.

Muirhead RJ. 1982. *Aspects of Multivariate Statistical Theory*. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Rencher AC. 2002. *Methods of Multivariate Analysis*. 2nd Ed. John Wiley.

Srivastava MS & Khatri CG. 1979. *An Introduction to Multivariate Statistics*. North Holland.

7. STAT 564 DESIGN OF EXPERIMENTS 2+1

Objective

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs involving one-way and two way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

Theory

UNIT I

Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions.

UNIT II

Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and blocks.

UNIT III

Basic designs - completely randomized design, randomized complete block design and Latin square design; orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares.

UNIT IV

Balanced incomplete block (BIB) designs – general properties and analysis without and with recovery of intra block information, construction of BIB designs. Partially balanced incomplete block designs with two associate classes - properties, analysis and construction, Lattice designs, general analysis of block designs.

UNIT V

Factorial experiments, confounding in symmetrical factorial experiments (2^n and 3^n series), partial and total confounding, fractional factorials, asymmetrical factorials.

UNIT VI

Designs for fitting response surface; Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments; Sampling in field experiments.

Practical

Determination of size and shape of plots and blocks from uniformity trials data; Analysis of data generated from completely randomized design, randomized complete block design; Latin square design, Youden square design; Analysis of data generated from a BIB design, lattice design, PBIB designs; 2^n, 3^n factorial experiments without and with confounding; Split and strip plot designs, Missing plot techniques, Analysis of covariance; Analysis of Groups of experiments, Sampling in field experiments.

Suggested Readings

Chakrabarti MC. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ. House.

Cochran WG & Cox DR. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Dey A & Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.

Dey A 1986. *Theory of Block Designs*. Wiley Eastern.

Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.

John JA & Quenouille MH. 1977. *Experiments: Design and Analysis*. Charles & Griffin.

Kempthorne, O. 1976. Design and Analysis of Experiments. John Wiley.

Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.

Kshirsagar AM 1983. *A Course in Linear Models*. Marcel Dekker.

Montgomery DC. 2005. *Design and Analysis of Experiments*. John Wiley.

Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.

Searle SR. 1971. *Linear Models*. John Wiley.

Street AP & Street DJ. 1987. *Combinatorics of Experimental Designs*. Oxford Science Publ.

Design Resources Server. *Indian Agricultural Statistics Research Institute(ICAR), New Delhi-110012, India*. www.iasri.res.in/design.

8. STAT 565 SAMPLING TECHNIQUES 2+1

Objective

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

Theory

UNIT I

Sample survey *vs* complete survey, probability sampling, sample space, sampling design, sampling strategy; Inverse sampling; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified random sampling, Number of strata and optimum points of stratification.

UNIT II

Ratio and regression methods of estimation, Cluster sampling, Systematic sampling, Multistage sampling with equal probability, Separate and combined ratio estimator, Double sampling, Successive sampling –two occasions**.**

UNIT III

Non-sampling errors – sources and classification, Non-response in surveys, Imputation methods, Randomized response techniques, Response errors – interpenetrating sub-sampling.

UNIT IV

Sampling with varying probabilities with and without replacement, PPS sampling, Cumulative method and Lahiri's method of selection, Horvitz- Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran. Inclusion probability proportional to size sampling, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling.

UNIT V

Unbiased ratio and regression type estimators, Multivariate ratio and regression type of estimators, Design effect, Bernoulli and Poisson sampling.

Practical

Determination of sample size and selection of sample; Simple random sampling, Inverse sampling, Stratified random sampling, Cluster sampling, systematic sampling; Ratio and regression methods of estimation; Double sampling, multi-stage sampling, Imputation methods; Randomized response techniques; Sampling with varying probabilities.

Suggested Readings

Cassel CM, Sarndal CE & Wretman JH. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.

Chaudhari A & Stenger H. 2005. *Survey Sampling Theory and Methods*. 2nd Ed. Chapman & Hall.

Chaudhari A & Voss JWE. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.

Cochran WG. 1977. *Sampling Techniques*. John Wiley.

Hedayat AS & Sinha BK. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.

Kish L. 1965. *Survey Sampling*. John Wiley.

Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Society, Calcutta.
Raj D & Chandhok P. 1998. *Sample Survey Theory*. Narosa Publ.
Sarndal CE, Swensson B & Wretman J. 1992. *Models Assisted Survey Sampling*. Springer.
Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
Thompson SK. 2000. *Sampling*. John Wiley.

9. STAT 566 STATISTICAL GENETICS 2+1

Objective

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

Theory

UNIT I

Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, combined estimation, disturbed segregation.

UNIT II

Gene and genotypic frequencies, Random mating and Hardy –Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, Theory of path coefficients.

UNIT III

Concepts of inbreeding, Regular system of inbreeding. Forces affecting gene frequency - selection, mutation and migration, equilibrium between forces in large populations, Random genetic drift, Effect of finite population size.

UNIT IV

Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning, Effect of inbreeding on quantitative characters, Multiple-allelism in continuous variation, Sex-linked genes, Maternal effects - estimation of their contribution.

UNIT V

Correlations between relatives, Heritability, Repeatability and Genetic correlation. Response due to selection, Selection index and its applications in plants and animals improvement programmes, Correlated response to selection.

UNIT VI

Restricted selection index. Variance component approach and linear regression approach for the analysis of GE interactions. Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability. Diallel and partial diallel crosses - construction and analysis.

Practical

Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation; Detection and estimation of linkage parameter by different procedures; Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law; Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient; Examination of effect of linkage, epistasis

and inbreeding on mean and variance of metric traits; Mating designs; Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection.

Suggested Readings

Bailey NTJ. 1961. *The Mathematical Theory of Genetic Linkage*. Clarendon Press.
Balding DJ, Bishop M & Cannings C. 2001. *Hand Book of Statistical Genetics*. John Wiley.
Crow JF & Kimura M. 1970. *An Introduction of Population Genetics Theory*. Harper & Row.
Dahlberg G. 1948. *Mathematical Methods for Population Genetics*. Inter Science Publ.
East EM & Jones DF. 1919. *Inbreeding and Outbreeding*. J B Lippincott.
Ewens WJ. 1979. *Mathematics of Population Genetics*. Springer.
Falconer DS. 1985. *Introduction to Quantitative Genetics*. ELBL.
Fisher RA. 1949. *The Theory of Inbreeding*. Oliver & Boyd.
Fisher RA. 1950. *Statistical Methods for Research Workers*. Oliver & Boyd.
Fisher RA. 1958. *The Genetical Theory of Natural Selection*. Dover Publ.
Kempthorne O. 1957. *An Introduction to Genetic Statistics*. The Iowa State Univ. Press.
Lerner IM. 1950. *Population Genetics and Animal Improvement*. Cambridge Univ. Press.
Lerner IM. 1954. *Genetic Homeostasis*. Oliver & Boyd.
Lerner IM. 1958. *The Genetic Theory of Selection*. John Wiley.
Li CC. 1982. *Population Genetics*. The University of Chicago Press.
Mather K & Jinks JL. 1977. *Introduction to Biometrical Genetics*. Chapman & Hall.
Mather K & Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.
Mather K. 1949. *Biometrical Genetics*. Methuen.
Mather K. 1951. *The Measurement of Linkage in Heredity*. Methuen.
Narain P. 1990. *Statistical Genetics*. Wiley Eastern.

10. STAT 567 REGRESSION ANALYSIS 1+1

Objective

This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.

Theory

UNIT I

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials.

UNIT II

Assumptions of regression; diagnostics and transformations; Examination of residuals ~ Studentized residuals, applications of residuals in detecting outliers, identification of influential observations. Lack of fit, Pure error. Testing homoscedasticity and normality of errors, Durbin-Watson test. Use of R^2 for examining goodness of fit.

UNIT III

Concepts of Least median of squares and its applications; Concept of multicollinearity, Analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation.

UNIT IV

Weighted least squares method: Properties, and examples. Box-Cox family of transformations. Use of dummy variables, Selection of variables: Forward selection, Backward elimination. Stepwise and Stagewise regressions.

UNIT V

Introduction to non-linear models, nonlinear estimation: Least squares for nonlinear models.

Practical

Multiple regression fitting with three and four independent variables; Estimation of residuals, their applications in outlier detection, distribution of residuals; Test of homoscedasticity, and normality, Box-Cox transformation; Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis; Least median of squares norm, Orthogonal polynomial fitting.

Suggested Readings

Barnett V & Lewis T. 1984. *Outliers in Statistical Data*. John Wiley.
Belsley DA, Kuh E & Welsch RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.
Chatterjee S, Hadi A & Price B. 1999. *Regression Analysis by Examples*. John Wiley.
Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
McCullagh P & Nelder JA. 1999. *Generalized Linear Models*. 2nd Ed. Chapman & Hall.
Montgomery DC, Peck EA & Vining GG. 2003. *Introduction to Linear Regression Analysis*. 3rd Ed. John Wiley.
Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

11. STAT 568 STATISTICAL COMPUTING 1+1

Objective

This course is meant for exposing the students in the concepts of computational techniques. Various statistical packages would be used for teaching the concepts of computational techniques.

Theory

UNIT I

Introduction to statistical packages and computing: data types and structures, pattern recognition, classification, association rules, graphical methods. Data analysis principles and practice

UNIT II

ANOVA, regression and categorical data methods; model formulation, fitting, diagnostics and validation; Matrix computations in linear models. Analysis of discrete data.

UNIT III

Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, numerical integration and Monte Carlo methods.

UNIT IV

Spatial statistics; spatial sampling; hierarchical modeling. Analysis of cohort studies, case-control studies and randomized clinical trials, techniques in the analysis of survival data and longitudinal studies, Approaches to handling missing data, and meta-analysis.

Practical

Data management, Graphical representation of data, Descriptive statistics; General linear models ~ fitting and analysis of residuals, outlier detection; Categorical data analysis, analysis of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.

Suggested Readings

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.
Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.
Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.
Gelman A & Hill J. 2006. *Data Analysis Using Regression and*

Multilevel/Hierarchical Models. Cambridge Univ. Press.
Gentle JE, Härdle W & Mori Y. 2004. *Handbook of Computational Statistics - Concepts and Methods*. Springer.
Han J & Kamber M. 2000. *Data Mining: Concepts and Techniques*. Morgan.
Hastie T, Tibshirani R & Friedman R. 2001. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer.
Kennedy WJ & Gentle JE. 1980. *Statistical Computing*. Marcel Dekker.
Miller RG Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. John Wiley.
Rajaraman V. 1993. *Computer Oriented Numerical Methods*. Prentice-Hall.
Ross S. 2000. *Introduction to Probability Models*. Academic Press.
Ryan BF & Joiner BL. 1994. *MINITAB Handbook*. 3rd Ed. Duxbury Press.
Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.
Snell EJ. 1987. *Applied Statistics: A Handbook of BMDP Analyses*. Chapman & Hall.
Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.
Venables WN & Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.

12. STAT 569 TIME SERIES ANALYSIS 1+1

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios based on time series data. It would also help them in understanding the concepts involved in time series data presentation, analysis and interpretation.

Theory

UNIT I

Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis.

UNIT II

Linear stationary models: Autoregressive, Moving average and Mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes.

UNIT III

Forecasting: Minimum mean square forecasts and their properties, Calculating and updating forecasts.

UNIT IV

Model identification: Objectives, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

Practical

Time series analysis, autocorrelations, correlogram and periodogram; Linear stationary model; Linear non-stationary model; Model identification and model estimation; Intervention analysis and outliers detection.

Suggested Readings

Box GEP, Jenkins GM & Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control*. 3rd Ed. Pearson Edu.
Brockwell PJ & Davis RA. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.
Chatterjee S, Hadi A & Price B.1999. *Regression* Analysis by Examples. John Wiley.
Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
Johnston J. 1984. *Econometric Methods*. McGraw Hill.

Judge GG, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.
Montgomery DC & Johnson LA. 1976. *Forecasting and Time Series Analysis*. McGraw Hill.
Shumway RH & Stoffer DS. 2006. *Time Series Analysis and its Applications: With R Examples*. 2nd Ed. Springer.

13. STAT 570 ACTUARIAL STATISTICS 2+0

Objective

This course is meant to expose to the students to the statistical techniques such as probability models, life tables, insurance and annuities. The students would also be exposed top practical applications of these techniques in computation of premiums that include expenses, general expenses, types of expenses and per policy expenses.

Theory

UNIT I

Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

UNIT II

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

UNIT III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT IV

Distribution of aggregate claims, compound Poisson distribution and its applications.

UNIT V

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

UNIT VI

Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

UNIT VII

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

UNIT VIII

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

UNIT IX

Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Suggested Readings

Atkinson ME & Dickson DCM. 2000. *An Introduction to Actuarial Studies*. Elgar Publ.

Bedford T & Cooke R. 2001. *Probabilistic Risk Analysis*. Cambridge.

Booth PM, Chadburn RG, Cooper DR, Haberman S & James DE. 1999.
Modern Actuarial Theory and Practice. Chapman & Hall.

Borowiak Dale S. 2003. *Financial and Actuarial Statistics: An Introduction. 2003*. Marcel Dekker.

Bowers NL, Gerber HU, Hickman JC, Jones DA & Nesbitt CJ. 1997.
Actuarial Mathematics. 2nd Ed. Society of Actuaries, Ithaca, Illinois.

Daykin CD, Pentikainen T & Pesonen M. 1994. *Practical Risk Theory for Actuaries*. Chapman & Hall.

Klugman SA, Panjer HH, Willmotand GE & Venter GG. 1998. *Loss Models: From data to Decisions*. John Wiley.

Medina PK & Merino S. 2003. *Mathematical Finance and Probability: A Discrete Introduction*. Basel, Birkhauser.

Neill A. 1977. *Life Contingencies*. Butterworth-Heinemann.

Rolski T, Schmidli H, Schmidt V & Teugels J. 1998. *Stochastic Processes for Insurance and Finance*. John Wiley.

Rotar VI. 2006. *Actuarial Models. The Mathematics of Insurance*. Chapman & Hall/CRC.

Spurgeon ET. 1972. *Life Contingencies*. Cambridge Univ. Press.

14. STAT 571 BIOINFORMATICS 2+0

Objective

Bioinformatics is a new emerging area. It is an integration of Statistics, Computer applications and Biology. The trained manpower in the area of Bioinformatics is required for meeting the new challenges in teaching and research in the discipline of Agricultural Sciences. This course is meant to train the students on concepts of basic biology, statistical techniques and computational techniques for understanding bioinformatics principals.

Theory

UNIT I

Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, markers, proteins and enzymes, bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

UNIT II

Computing techniques: OS and Programming Languages – *Linux, perl, bioperl, cgi, MySQL, phpMyAdmin*; Coding for browsing biological databases on web, parsing & annotation of genomic sequences; Database designing; Computer networks – Internet, World wide web, Web browsers – EMBnet, NCBI; Databases on public domain pertaining to Nucleic acid sequences, protein sequences, SNPs, etc.; Searching sequence databases, Structural databases.

UNIT III

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

UNIT IV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pairwise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pairwise database searching; Sequence analysis– BLAST and other related tools, Multiple alignment and database search using motif models, ClustalW, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments

Suggested Readings

Baldi P & Brunak S. 2001. *Bioinformatics: The Machine Learning Approach.* 2nd Ed. (Adaptive Computation and Machine Learning). MIT Press.

Baxevanis AD & Francis BF. (Eds.). 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley.

Bergeron BP. 2002. *Bioinformatics Computing*. Prentice Hall.

Duda RO, Hart PE & Stork DG. 1999. *Pattern Classification*. John Wiley.

Ewens WJ & Grant GR. 2001. *Statistical Methods in Bioinformatics: An Introduction* (*Statistics for Biology and Health*). Springer.

Hunt S & Livesy F. (Eds.). 2000. *Functional Genomics: A Practical Approach* (*The Practical Approach Series, 235*). Oxford Univ. Press.

Jones NC & Pevzner PA. 2004. *An Introduction to Bioinformatics Algorithims*. MIT Press.

Koski T & Koskinen T. 2001. *Hidden Markov Models for Bioinformatics*. Kluwer.

Krane DE & Raymer ML. 2002. *Fundamental Concepts of Bio-informatics*. Benjamin / Cummings.

Krawetz SA & Womble DD. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.

Lesk AM. 2002. *Introduction to Bio-informatics*. Oxford Univ. Press.

Percus JK. 2001. *Mathematics of Genome Analysis*. Cambridge Univ. Press.

Sorensen D & Gianola D. 2002. *Likelihood, Bayesian and MCMC Methods in Genetics.* Springer.

Tisdall JD. 2001. *Mastering Perl for Bioinformatics*. O'Reilly & Associates.

Tisdall JD. 2003. B*eginning Perl for Bioinformatics*. O'Reilly & Associates.

Wang JTL, Zaki MJ, Toivonen HTT & Shasha D. 2004. *Data Mining in Bioinformatics*. Springer.

Wu CH & McLarty JW. 2000. *Neural Networks and Genome Informatics*. Elsevier.

Wunschiers R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming*. Springer.

15. STAT 572 ECONOMETRICS 2+0

Objective

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles.

Theory

UNIT I

Representation of Economic phenomenon, relationship among economic variables, linear and non linear economic models, single equation general linear regression model, basic assumptions, Ordinary least squares method of estimation for simple and multiple regression models; summary statistics correlation matrix, co-efficient of multiple determination, standard errors of estimated parameters, tests of significance and confidence interval estimation. BLUE properties of Least Squares estimates. Chow test, test of improvement of fit through additional regressors. Maximum likelihood estimation.

UNIT II

Heteroscedasticity, Auto-correlation, Durbin Watson test, Multicollinearity. Stochastic regressors, Errors in variables, Use of instrumental variables in regression analysis. Dummy Variables. Distributed Lag models: Koyck's Geometric Lag scheme, Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

UNIT III

Simultaneous equation model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification, Indirect Least Squares, Two-stage least squares, K-class estimators, Limited Information and Full Information Maximum Likelihood Methods, Three stage least squares, Generalized least squares, Recursive models, SURE Models. Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

UNIT IV

Problem and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

UNIT V

Demand analysis – Demand and Supply Curves; Determination of demand curves from market data. Engel's Law and the Engel's Curves, Income distribution and method of its estimation, Pareto's Curve, Income inequality measures.

Suggested Readings

Croxton FE & Cowden DJ. 1979. *Applied General Statistics*. Prentice Hall of India.

Johnston J. 1984. *Econometric Methods*. McGraw Hill.

Judge GC, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988.
Introduction to the Theory and Practice of Econometrics. 2nd Ed. John Wiley.

Kmenta J. 1986. *Elements of Econometrics*. 2nd Ed. University of Michigan Press.

Koop G. 2007. *Introduction to Econometrics*. John Wiley.

Maddala GS. 2001. *Introduction to Econometrics*. 3rd Ed. John Wiley.

Pindyck RS & Rubinfeld DL. 1998. *Econometric Models and Economic Forecasts*. 4th Ed. McGraw Hill.

Verbeek M. 2008. *A Guide to Modern Econometrics*. 3rd Ed. John Wiley.

16. STAT 573 STATISTICAL QUALITY CONTROL 2+0

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control. students who do not have sufficient background of Statistical Methods.

Theory

UNIT I

Introduction to Statistical Quality Control; Control Charts for Variables – Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups.

UNIT II

Control charts for attributes- 'np', 'p' and 'c' charts.

UNIT III

Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.

UNIT IV

Sampling inspection tables for selection of single and double sampling plans.

Suggested Readings

Cowden DJ. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.
Dodge HF & Romig HG. 1959. *Sampling Inspection Tables*. John Wiley.
Duncan A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.
Grant EL & Leavenworth RS. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.
Montgomery DC. 2005. *Introduction to Statistical Quality Control*. 5th Ed. John Wiley.
Wetherhil G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press.

17. STAT 574 OPTIMIZATION TECHNIQUES 1+1

Objective

This course is meant for exposing the students to the mathematical details of the techniques for obtaining optimum solutions under constraints for desired output. They will be taught numerical methods of optimization, linear programming techniques, non-linear programming and multiple objective programming. Students will also be exposed to practical applications of these techniques.

Theory

UNIT I

Classical Optimization Techniques: Necessary Conditions for an Extremum. Constrained Optimization: Lagrange Multipliers, Statistical Applications. Optimization and Inequalities. Classical Inequalities, like Cauchy-Schwarz Inequality, Jensen Inequality and Markov Inequality.

UNIT II

Numerical Methods of Optimization: Numerical Evaluation of Roots of Equations, Direct Search Methods, Sequential Search Methods – Fibonacci Search Method. Random Search Method – Method of Hooke and Jeeves, Simplex Search Method. Gradient Methods, like Newton's Method, and Method of Steepest Ascent. Nonlinear Regression and Other Statistical Algorithms, like Expectation – Maximization Algorithm.

UNIT III

Linear programming Techniques – Simplex Method, Karmarkar's Algorithm, Duality and Sensitivity Analysis. Zero-sum Two-person Finite Games and Linear Programming. Integer Programming. Statistical Applications.

UNIT IV

Nonlinear Programming and its Examples. Kuhn-Tucker Conditions. Quadratic Programming. Convex Programming. Basics of Stochastic Programming. Applications. Elements of Multiple Objective Programming. Dynamic Programming, Optimal Control Theory – Pontryagin's Maximum Principle, Time-Optimal Control Problems.

Practical

Problems based on classical optimization techniques; Problems based on optimization techniques with constraints; Minimization problems using numerical methods; Linear programming (LP) problems through graphical method; LP problem by Simplex method; LP problem using simplex method (Two-phase method); LP problem using primal and dual method; Sensitivity analysis for LP problem; LP problem using Karmarkar's method; Problems based on Quadratic programming; Problems based on Integer programming; Problems based on Dynamic programming; Problems based on Pontryagin's Maximum Principle.

Suggested Readings

Rao SS. 2007. *Engineering Optimization: Theory and Practice*. 3rd Ed. New Age.

Rustagi JS. 1994. *Optimization Techniques in Statistics*. Academic Press.

Taha HA. 2007. *Operations Research: Introduction with CD*. 8th Ed. Pearson Edu.

Zeleny M. 1974. *Linear Multiobjective Programming*. Springer.

18. STAT 575 DEMOGRAPHY 2+0

Objective

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principles involved in bioassays.

Theory

UNIT I

Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures.

UNIT II

Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables.

UNIT III

Stationary and stable populations, Migration and immigration. Application of stable population theory to estimate vital rates, migration and its estimation. Demographic relations in Nonstable populations. Measurement of population growth, Lotka's model(deterministic) and intrinsic rate of growth, Measures of mortality and morbidity, Period and

UNIT IV

Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays quantal responses, probit and logit transformations, epidemiological models.

Suggested Readings

Cox DR. 1957. *Demography*. Cambridge Univ. Press.

Finney DJ. 1981. *Statistical Methods in Biological Assays*. Charles Griffin.

Fleiss JL. 1981. *Statistical Methods for Rates and Proportions*. John Wiley.
Lawless JF. 1982. *Statistical Models and Methods for Lifetime Data*. John Wiley.
MacMahon B & Pugh TF. 1970. *Epidemiology- Principles and Methods*. Little Brown, Boston.
Mann NR, Schafer RE & Singpurwalla ND. 1974. *Methods for Statistical Analysis of Reliability and Life Data*. John Wiley.
Newell C. 1988. *Methods and Models in Demography*. Guilford Publ.
Preston S, Heuveline P & Guillot M. 2001. *Demography: Measuring and Modeling Population Processes*. Blackwell Publ.
Rowland DT. 2004. *Demographic Methods and Concepts*. Oxford Press.
Siegel JS & Swanson DA. 2004. *The Methods and Material of Demography*. 2nd Ed. Elsevier.
Woolson FR. 1987. *Statistical Methods for the Analysis of Biomedical Data*. John Wiley.

19. STAT 576 STATISTICAL METHODS FOR LIFE SCIENCES 2+0

Objective

This course focuses on statistical methods for discrete data collected I in public health, clinical and biological studies including survival analysis. This would enable the students to understand the principles of different statistical techniques useful in public health and clinical studies conducted.

Theory

UNIT I

Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models.

UNIT II

Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications. Analysis of survival time data using parametric and nonparametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

UNIT III

Proportional Hazard model: Methods of estimation, estimation of survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structural models.

UNIT IV

General theory for developing locally efficient estimators of the parameters of interest in censored data models. Rank tests with censored data. Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications.

UNIT V

Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlo methods.

Suggested Readings

Biswas S. 1995. *Applied Stochastic Processes. A Biostatistical and Population Oriented Approach*. Wiley Eastern Ltd.
Collett D. 2003. *Modeling Survival Data in Medical Research*. Chapman & Hall.
Cox DR & Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.
Hosmer DW Jr. & Lemeshow S. 1999. *Applied Survival Analysis:*

Regression Modeling or Time to Event. John Wiley.
Klein JP & Moeschberger ML. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.
Kleinbaum DG & Klein M 2005. *Survival Analysis. A Self Learning Text*. Springer.
Kleinbaum DG & Klein M. 2005. *Logistic Regression*. 2nd Ed. Springer.
Lee ET. 1992. *Statistical Methods for Survival Data Analysis*. John Wiley.
Miller RG. 1981. *Survival Analysis*. John Wiley.
Therneau TM & Grambsch PM. 2000. *Modeling Survival Data: Extending the Cox Model*. Springer.

20. STAT 577 STATISTICAL ECOLOGY 2+0

Objective
This course is meant for exposing the students to the importance and use ofstatistical methods in collections of ecological data, species-abundance relations, community classification and community interpretation.

Theory
UNIT I
Ecological data, Ecological sampling; Spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distance methods.
UNIT II
Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, interspecific association, interspecific covariation.
UNIT III
Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.
UNIT IV
Community interpretation: Classification Interpretation and Ordination Interpretation.

Suggested Readings
Pielou EC. 1970. *An introduction to Mathematical Ecology*. John Wiley.
Reynolds JF & Ludwig JA. 1988. *Statistical Ecology: A Primer on Methods and Computing*. John Wiley.
Young LJ, Young JH & Young J. 1998. *Statistical Ecology: A Population Perspective*. Kluwer.

2. Service / Minor/ Supporting Courses on Agricultural Statistics
(For M.Sc. and Ph.D. programs of all disciplines)

1. STAT 500 APPLIED MULTIVARIATE ANALYSIS 1+1

Objective
This course is meant for Extension / Home Science and other students of the doctoral level dealing with quantitative and qualitative data on number of variables simultaneously.
UNIT I
Simple, Partial and Multiple correlations and regressions Multivariate Normal distributions.
UNIT II
Hotellings T^2 and Mahalanobis D^2, Disriminant functions

UNIT III

Multivariate Analysis of variance, Principal component analysis, Canonoical correlations and factor analysis.

Practicals

Problems on simple, partial and multiple correlation coefficients, Linear and non linear regression equations, Multivariate normal distributions and Manova, Tests based on Hotellings T^2 and Mahalanobis D^2. Discriminant functions, Principal component analysis, factor analysis and canonical correlations.

Suggested Readings

Anderson TW. 1984. *An Introduction to Multivariate Statistical Analysis*. 2nd Ed. John Wiley.

Giri NC. 1977. *Multivariate Statistical Inference*. Academic Press.

Johnson RA & Wichern DW. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.

Rencher AC. 2002. *Methods of Multivariate Analysis*. 2nd Ed. John Wiley.

Srivastava MS & Khatri CG. 1979. *An Introduction to Multivariate Statistics*. North Holland.

2. STAT 501: MATHEMATICAL METHODS FOR APPLIED SCIENCE 3+0

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. Recommended for Post graduate students from the Departments of Home Science, Agricultural Economics, and Agricultural Extension.

Theory

UNIT I

Variables and functions; limit and continuity. Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization.

UNIT II

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics and engineering.

UNIT III

Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and eigen vectors. Determinants - evaluation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis.

UNIT IV

Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets.

Suggested Readings

Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*.Springer.

Hohn FE. 1973. *Elementary Matrix Algebra*. Macmillan.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Stewart J. 2007. *Calculus*. Thompson.

Thomas GB. Jr. & Finney RL. 1996. *Calculus.* 9th Ed. Pearson Edu.

3. STAT 502 NUMERICAL ANALYSIS 2+0

Objective

The primary objective of the course is to develop the basic understanding of the construction of numerical algorithms, and perhaps more importantly, the applicability and limits of their appropriate use.

Theory

UNIT I

Introduction to complex variables; Basic concepts: Floating point number system, Implication of finite precision, Rounding off errors.

UNIT II

Interpolation: Polynomial interpolation, Inverse interpolation, Spline interpolation; Numerical integration: Trapezoidal rule, Simpson's 1/3rd and 3/8th rules; Ordinary differential equations: Runge-Kutta methods, Predictor - corrector methods.

UNIT III

Linear system of equations: Gaussian's elimination, Operation counts, Implementation including pivoting and scaling, Direct factorization methods, Iterative techniques and their analysis.

UNIT IV

Linear Difference equations; Non-linear equations : Bisection, Newton Raphson, false positions, Secant methods, Iterative methods.

UNIT V

Inverse of Matrices; Computation of eigen values and eigen vectors: Error estimates, the power methods – Jaccobi and Householder Method.

UNIT VI

Exposure to mathematical software packages.

Suggested Readings

Atkinson KE & Han W. 2003. *Elementary Numerical Analysis*. 3rd Ed. John Wiley.

Atkinson KE. 1978. *An Introduction to Numerical Analysis*. John Wiley.

Jain MK, Iyengar SRK & Jain RK. 2007. *Numerical Methods for Scientific and Engineering Computation*. 7th Ed. New Age.

Kennedy WJ & Gentle JE. 1980. *Statistical Computing*. Marcel Dekker.

Krishnamurthi EV & Sen SK. 1986. *Computer – Based Numerical Algorithms*. East West Publ.

Yakowitz S & Szidarovszky F. 1986. *An Introduction to Numerical Computation*. MacMil

4. STAT 503 MATHEMATICAL FOUNDATIONS IN COMPUTER SCIENCE 3+0

Objective

This course is designed to give basic foundations in mathematics that are needed to complement and improve the understanding of courses based on algorithm and problem solving.

Theory

UNIT I

Sets: Set theory, subsets, operations on sets, set cardinality and counting.

UNIT II

Functions: Bijective functions, pigeon-hole principle, Boolean functions, permutation functions, Boolean algebra, recursion relations.

UNIT III

Number Theory: Binary arithmetic, exponentiation, induction, sequences, big-oh notation, GCD, Euclidean algorithm, partially ordered sets, congruence and equivalence relation, encryption scheme, Fibonacci sequence, linear homogenous recurrence relations with constant coefficients.

UNIT IV

Graph Theory: Graphs, trees, LAN, Eulerian cycles, Hamiltonian cycles, graph coloring, graph algorithms.

UNIT V

Mathematical Logic: Propositional calculus, proposition, logic connectives and compound statements, conjunction, disjunction, truth tables, duality, tautologies and fallacies.

UNIT VI

Algebraic Systems: Sub semi groups, subgroups and cosets, homomorphisms, application of groups to counting, ring, integral domain and field.

Suggested Readings

Abertson MO & Hutchinson JP. 1988. *Discrete Mathematics with Algorithms*. John Wiley.

Deo N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.

Knuth DE. 1968. *Art of Computer Programming*. Vol. I. *Fundamental Algorithms*. Addison Wesley.

Tremblay JP & Manohar RP. 1975. *Discrete Mathematical Structures with Applications to Computer Science*. McGraw Hill.

5. STAT 504 DATA PROCESSING (1+1)

Objective

To develop understanding about data processing techniques and enables students in handling analyzing and presentation of data.

Theory

Data processing- Concept and technique, Graphical presentation of data, Computer application in data processing.

Practical

Practicing various techniques of data processing and presentation of data through computer.

Suggested readings:

Bajpai S.R. 1969, Methods of Social Survey and research, Kitab Ghar.

Carter Good, V. 1966. Essential of Education Research. AQppelton Century Profits, Educational division, Mereelith Corp.

6. STAT 505 OPERATIONS RESEARCH (2+1)

Objective

The objective of this course is to acquire the learner the applications of some operations research techniques . Focus will be on understanding the use of these techniques in solving business problems.

Theory

UNIT I

Linear programming: Objective assumptions, Formulation of linear programming problems, Graphic method, Simplex method, Transportation and assignment problems.

UNIT II

Inventory control models, Costs involved in inventory management. Types of inventory. Economic order quantity (EOQ) model. Continuous review (Q) system. Periodic review (P) system. Hybrid system, Simulation

UNIT III

Waiting line models. waiting line problem. Characteristics of a waiting. Line system, Single channel model. Multiple channel model, Constant service, Time model, finite population model. Sequencing and replacement models.

UNIT IV

Decision making under risk and uncertainties. Decision problem, maximal criterion.Minimum criterion, Minimax regret criterion. Laplace criterion, Pay off tables, decision trees, Expected value of perfect information

UNIT V

Game theory, Two person Zero Sum game, Simulation, Network analysis PERT and CPM

Practical

Problems and applications based on the above topic.

Suggester readings

Cook, T.M. and Russell R.A. 1989 Introduction to management Science Prentice hall.

Taha, H.A. Operations research- An introduction, Printce Hall.

Vohra, N.D. 2006, Quantitative techniques in management Mc Graw Hill

Wagner, H.M. 2005, Principles of Operations Research.

7. STAT 506 BIOSTATISTICS AND COMPUTER APPLICATIONS (2+1)

Objective

This is a special course for M.Sc. Students of Biotechnology and other related disciplines. They are exposed to various Statistical methods to analyse their experimental data.

Theory

UNIT I

Aims, scope and idea of elementary statistics; Measures of central tendency and dispersion, Skewness and Kurtosis.

UNIT II

Concept of probability and probability laws, mathematical expectation, moments, moment generating function, Standard probability distributions- Binomial, Poisson and Normal distributions.

UNIT III

Test of Significance based on Z, χ^2 , t and F distributions; Correlation and regression, Curve fitting by least square methods.

UNIT IV

Basic Principles, Organisation and Operational aspects of computers, Operating systems, Introduction to MS- Office, Ms Word, MS Excel. Statistical data analysis based on above topics through MS- Excel

Practical

i. Data analysis using probability, tests of significance.

ii. Correlation and regression analysis

iii. Usage of MS- Windows
iv. Exercises on test processing, spread sheet and DBMS.
v. SPSS

Suggested Readings

Agarwal, B. L. 2003, Basic Statistics, New Age
Gupta, S.P. 2004 , Statistical Methods, S. Chand and Sons.
Dutta, N.K. 2002. Fundamentals of Biostatistics, Kanishka Publ.

8. COMPUTER APPLICATIONS FOR MANAGEMENT 2+1

Objective

This Course is aimed at equipping the learner the basic computing skills and to remain abreast of changing technology throughout their career.

Theory

UNIT I

Introduction to IT: Softwares, system software, Operating systems-Single task and Multitask operating systems, Compiler and Interpreter,Real time and Online systems, Batch Processing, Multi programming, Time sharing systems, Basics of Data communication,- Communication channels, Data compression and encryption, Data transmission,, Electronic Mail, Internet connectivity, local area net working, types of net works, WAN technology, ISDN, VSAT, network standardization, areas of standardization, Network components, HUB, SWITCH,MODEM, ROUTER, Network topology, BUS, Ring, Star, Tree, Mesh.

UNIT II

Information concepts and Processing, Concepts of information, Definition of information and example of information, Difference between data and information, data concepts, examples of data types, logical concepts of data, entities, attributes and relationships, physical concepts, storage and retrieval, Organisation of data as a file, - Elements of Electronic data processing,- Overview of Commercial application, Billing and Accounting, Processing Methodologies, Introduction to data base package- ACCESS/ ORACLE/ SQL; Creation of database using any one of the above packages and generation of forms and reports.

UNIT III

SPSS, Importing data from EXCEL into SPSS, Creation of linear and exponential graphs, Finding compound growth rate; Correlation and regression.

UNIT IV

Tally: Basics of accounting, Definition- double entry/ Single entry, Classification of items, assets liabilities and expenses, income – capital, Rules for debit and Credit, Final accounts, Costing, Definition, Cost centres, Budget, - Various types of Budget. Advantages of Computerised accounting system. Financial accounting using Computer – Tally; Features of Tally, Accounts organization, Creation of different entries using the package. – Company information, Account information. Day book, list of accounts, Account book, trial balance, Cash / Funds flow, Vouchers entry, Preparation of P and L accounts, Balance sheet using the package, ratio analysis, Inventory and statements of inventory, Taking soft copy and hard copy Using the package.

UNIT V

Introduction to HTML, HTML tags, Marquee, Font size, BG Colour, < HI>, <U>, < IMG SR>, < EMBED SR>, <LI>, <UL>, < a HREF >, < TABLE >, <TR>, <TD>, Creation of Webpage using HTML Tags.

UNIT VI

Introduction to E Commerce Models, Business to Consumer, Business to Business, Consumer to Business, Consumer to Consumer, Recent developments in IT

Practical

Managing different data types, Creation of tables, Linking different tables using Primary key and secondary key concept, Creation of queries, forms, reports. Statistical Analysis using Excel and SPSS(Mean , Median, Mode, variance, Standard deviation, Correlation and Regression. Mathematical and Financial functions, Pivot table reports, Sorting and Grouping, Creation of Graphs,(Columns, Pie, line, Scatter diagrams), Filtering data, Preparation of balance sheet. Profit and Loss account – Ratio analysis using Tally. HTML Tags, Creation of Web page using HTML.

Suggested Readings:

Elias M Award, Malcom H Gotterer 1992, Database Management: Boyd and Fraser Publishing Company.

SPSS: SPSS Manual

Ivan Bayross; Commercial Application Development using Oracle 2000- BPB Publication

Kamalesh K. Bajaj , Debjani Nag. 1999 E- Commerce:- The cutting edge of Business- Tata Mc GrawHill

K.K. Nadhani 1999 Acconting with Tally- BPB Publication.

Steven Holzner, 2007 HTML , Dreamtech.

Kathy Jacobs , 2007 . Microsoft Office Excel, The L Line The express line to learning, Wiley India Publications..

9. STAT 508 COMPUTERS- FUNDAMENTALS AND PROGRAMMING 2+1

Objective

This course builds an understanding of the structure of computers and how they execute programs, data representation and computer arithmetic. The course is also aimed to develop problem-solving strategies, techniques and skills to help students develop the logic, ability to solve the problems efficiently using C programming. A service course suggested for all disciplines.

Theory

UNIT I

Computer Fundamentals - Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, character representation; ASCII, EBCDIC.

UNIT II

Programming Fundamentals with C - Algorithm, techniques of problem solving, flowcharting, stepwise refinement; Representation of integer, character, real, data types; Constants and variables; Arithmetic expressions, assignment statement, logical expression.

UNIT III

Sequencing, alteration and iteration; Arrays, string processing. Sub-programs, recursion.

UNIT IV

Program correctness; Debugging and testing of programs.

Practical

Conversion of different number types; Creation of flow chart, conversion of algorithm / flowchart to program; Mathematical operators, operator precedence; Sequence, control and iteration; Arrays and string processing; File processing.

Suggested Readings

Balaguruswamy E. 1998. *Programming with ANSI C*. Tata McGraw Hill.
Gottfried B. 1999. *Programming with C, Schaum Outline Series*. Tata McGraw Hill.
Kanetkar Y. 1999. *Let Us C*. BPB Publ.
Malvino AP & Brown JA. 1999. *Digital Computer Electronics*. Tata McGraw Hill.
Mano MM. 1999. *Digital Logic and Computer Design*. Prentice Hall of India.

10. STAT 509 INTRODUCTION TO NETWORKING AND INTERNET APPLICATIONS 1+1

Objective

The course is aimed to provide fundamentals of networking and application protocols with the emphasis on developing web based applications. A service course suggested for all disciplines.

Theory

UNIT I

Networking fundamentals, types of networking, network topology; Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer, Protocol (SMTP).

UNIT II

World Wide Web (WWW), working with Internet; Web pages, web sites, web servers; Web Applications.

UNIT III

Hyper Text Markup Language (HTML), DHTML, web based application development.

Practical

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and Creation of websites using DHTML.

Suggested Readings

Buyens J. 2002. *Microsoft FrontPage -Inside Out.* Microsoft Press.
Cox V, Wermers L & Reding EE. 2006. *HTML Illustrated Complete*. 3rd Ed. Course Technology.
Niederst J. 2001. *Web Design in a Nutshell*. O'Reilly Media.
Tanenbaum AS. 2003. *Computer Networks*. Prentice Hall of India.

11. STAT 510 DATA BASE MANAGEMENT SYSTEMS 2+1

Objective

Database systems are backbone of any information system, enterprise resource planning, research activities and other activity that require permanence of data storage. This course provides the basic introduction to database system technologies; design, concurrency, security and backup/recovery issues of database management systems. The major focus in this course is the Relational database model.

Theory

UNIT I

Database system - Operational Data, Characteristics of database approach, architecture.

UNIT II

Overview of DBMS; Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification.

UNIT III
Entity Relationship model; Relational Data Structure- Relations, Domains and Attributes. Relational Database Design.
UNIT IV
Concepts and principles of data ware housing; data warehousing architecture, data warehousing, design, database schema
UNIT V
Introduction to data mining, Visualization techniques, decision trees, Association rules, Statistical and clustering models.

Practical

E-R diagram construction; SQL - Command Syntax, Data types, DDL Statements, DML Statements, integrity constraints; Triggers, creating stored procedures/ functions;. Data warehouse design, Selection of schema, Data ware mining techniques.

Suggested Readings

Date CJ. 2000. *Introduction to Database System*. Addison Wesley.
Desai BC. 2000. *Introduction to Database Systems*. Galgotia Publ.
Elmasri & Navathe. 2006. *Fundamentals of Database Systems*. 4th Ed. Addison Wesley.
Garcia-Molina H, Ullman JD & Widom J. 2002. *Database Systems: The Complete Book*. Prentice Hall.
Rob P & Coronel C. 2006. *Database Systems: Design, Implementation and Management*. 7th Ed. Thomson Learning.
Silberschartz A, Korth HF & Sudarshan S. 1997. *Database Systems Concepts*. Tata McGraw Hill.

12. STAT 502 STATISTICAL METHODS FOR APPLIED SCIENCES (2+1)

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. It would help them in understanding the concepts involved in data presentation, analysis and interpretation and also for taking other supporting courses on Agricultural Statistics. The course is useful to students of all other disciplines especially to students of social sciences

Theory

UNIT I
Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation.
UNIT II
Discrete and continuous probability distributions: Binomial, Poisson and Normal distribution. Concept of sampling distribution: chi-square, *t* and *F* distributions. Tests of significance based on Normal, chi-square, *t* and *F* distributions. Large sample theory.
UNIT III
Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

UNIT V

Introduction to multivariate analytical tools- Classificatory problems and discriminant function, D^2-statistic and its applications; Cluster analysis, Principal component analysis and factor analysis

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Confidence interval, Interval estimation and point estimation of parameters of Binomial, Poisson and Normal distribution; Correlation and regression analysis, Non parametric tests, Discriminant function analysis, D^2 analysis and factor analysis.

Suggested Readings

Anderson TW. 1958. *An Introduction to Multivariate Statistical Analysis*. John Wiley.

Dillon WR & Goldstein M. 1984. *Multivariate Analysis - Methods and Applications*. John Wiley.

Goon AM, Gupta MK & Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.

Hoel PG. 1971. *Introduction to Mathematical Statistics*. John Wiley.

Hogg RV & Craig TT. 1978. *Introduction to Mathematical Statistics*. Macmillan.

Morrison DF. 1976. *Multivariate Statistical Methods*. McGraw Hill.

Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.

Learning Statistics: http://freestatistics.altervista.org/en/learning.php.

Electronic Statistics Text Book:
http://www.statsoft.com/textbook/stathome.html.

13. STAT 512 EXPERIMENTAL DESIGNS 2+1

Objective

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs - randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missingplot techniques in randomized block and Latin square designs;Transformations, crossover designs, balanced incomplete block design, Lattice design, Response surfaces.

UNIT V

Bioassays- direct and indirect, potency estimation.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Fitting of response surfaces and Bioassays.

Suggested Readings

Cochran WG & Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Federer WT. 1985. *Experimental Designs*. MacMillan.

Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.

Nigam AK & Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publication

Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

Design Resources Server: www.iasri.res.in /design.

14. STAT 513 SAMPLING TECHNIQUES 2+1

Objective

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

Theory

UNIT I

Concept of sampling, sample survey *vs* complete enumeration, planning of sample survey, sampling from a finite population. sampling and non-sampling errors; Preparation of questionnaire ,Non-sampling errors.

UNIT II

Simple random sampling, sampling for proportion, determination of sample size; inverse sampling, Stratified sampling. Ratio and regression estimators.

UNIT III

Cluster sampling, PPS sampling, Multi-stage sampling, double sampling, systematic sampling; Use of auxiliary information at estimation as well as selection stages.

Practical

Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.; simple random sampling, determination of sample size; stratified sampling, cluster sampling and systematic sampling; Estimation using ratio and regression estimators; Estimation using multistage design, double sampling and PPS sampling.

Suggested Readings

Cochran WG. 1977. *Sampling Techniques*. John Wiley.

Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
Singh D, Singh P & Kumar P. 1982. *Handbook on Sampling Methods*. IASRIPublication.
Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

15. STAT 521 APPLIED REGRESSION ANALYSIS 2+1

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multicollinearity and heteroscedasticity for those students of Economics and Management.

Theory

UNIT I

Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

UNIT II

Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT III

Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

UNIT IV

Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose.

Practical

Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves.

Suggested Readings

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.
Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. *Applied Regression Analysis and Multivariable Methods*. Duxbury Press.
Koutsoyiannis A. 1978. *Theory of Econometrics*. MacMillan.
Kutner MH, Nachtsheim CJ & Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

16. STAT 531 DATA ANALYSIS USING STATISTICAL PACKAGES 2+1

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students an hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

UNIT I

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.

UNIT III

Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons.

UNIT IV

Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, One way analysis of variance , contrast and its testing, pairwise comparisons; Factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; testing and significance of contrasts, Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Fitting of growth models - curve estimation models, Examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component; Analysis of time series data -.

Suggested Readings

Anderson CW & Loynes RM. 1987. *The Teaching of Practical Statistics*. John Wiley.

Atkinson AC. 1985. *Plots Transformations and Regression*. Oxford University Press.

Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.

Chatfield C & Collins AJ. 1980. *Introduction to Multivariate Analysis*. Chapman & Hall.

Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.

Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.

Cleveland WS. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.

Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.

Erickson BH & Nosanchuk TA. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
Snell EJ & Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman & Hall.
Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
Velleman PF & Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.
Wetherill GB.1986. *Regression Analysis with Applications*. Chapman & Hall.
Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
Course on Experimental design:
http://www.stat.sc.edu/~grego/courses/stat706/.
Design Resources Server: www.iasri.res.in/design.
Analysis of Data: Design Resources Server.
http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%2
Data.html.

17. STAT 532 APPLIED STATISTICAL GENETICS 2+1

Objective

This course is proposed considering the requirement of students of Plant Breeding and Genetics, Biotechnology and Horticulture who are interested to study the application of Statistics to Genetical and Molecular applications.

UNIT I

Mendelian ratios and their testing, Linkage, detection and estimation, Equilibrium population and Hardy Weinberg law. Inbreeding, Inbreeding coefficient and Coefficient of Parentage, Inbreeding under regular systems of mating, Estimation and testing of Heterosis.

UNIT II

Average effect of a gene, Breeding value, Estimation of Genetic components of variation, Heritability and Repeatability, Estimation of Phenotypic, Genotypic and Environmental correlations. Selection, Individual and pedigree selection.

UNIT III

Designs for plant Breeding trials- Compact family block designs, Square and rectangular lattice designs. Multivariate analysis of variance, Cluster analysis, Similarity algorithms and Clustering methods for qualitative and quantitative data, Principal component analysis, Principal co-ordinate analysis,

UNIT IV

Multiple correlations, Regression and Path analysis, Discriminant analysis,. Selection indices. Generation mean analysis

UNIT V

Analysis of Genotype environment interactions, Measurement of stability and adaptability-Liner and non linear approaches. Combining ability, Analysis of designs for Diallel, Partial diallel and line x tester crosses.

Practical

Introduction- Mendelian ratios and their testing. Finding linkage in coupling and repulsion phase. Detection of linkage (χ^2 test)- Recombination fraction. Estimation of linkage, different methods, Gene and Genotypic frequency, Random mating population, Hardy Weinberg law. Resemblance between individuals, Inbreeding, inbreeding coefficient and coefficient of parentage. Inbreeding under regular systems of mating. Heterosis- Breeding value, Estimation of Genetic components of variation. Heritability and repeatability, Estimation of Phenotypic, genotypic and Environmental correlations.

Analysis data with different type of crosses. Partitioning of sum of squares into components- Compact family block designs, Lattice designs – construction and analysis Similarity and divergence measures- Clustering methods for qualitative and quantitative data- Dendrogram, Metroglyphs, D^2, Principal component analysis and Principal co-ordinate analysis, Discriminant functions and selection indices. Generation mean analysis. Path analysis Stability analysis- Linear and non linear methods. Combining ability and Diallel analysis

Suggested reading:

Cochran W.G. and Cox, D. R. (1957). *'Experimental Designs'* , John Wiley

Dabholkar, A.R. (1992) *'Elements of Biometrical Genetics'* . Concept Publishing Company, New Delhi

Das, M.N. and Giri,N.C.(1991) *'Design and Analysis of Experiments'* Wiley Eastern , New Delhi

Falconer, D.S. (1985). *'Introduction to Quantitative Genetics*, English Language Book Society, Longman

Jain , J.P. (1991) . *'Statistical Techniques in Quantitative Genetics'*, Hindusthan Publishing Company, New Delhi

Kempthorne, O. (1957). *'An introduction to Genetic Statistics'*, The Iowa State University Press, London

Kempthorne ,O. (1976). *'Design and analysis of Experiments'*, John Wiley

Krzanowski,W.J.(1988). *'Principles of Multivariate analysis – A user's Perspective'* Clarendon Press-Oxford Statistical Science Series.

Li, C.C. (1982). *'Population Genetics'*. The University of Chicago Press

Mather, K. and Jinks J.L. (1977) . *'Introduction to Biometrical Genetics'*, Chapman and Hall

Montgomery, D.C. (2005) *'Design and Analysis of Experiments'*, John Wiley.

NageswaraRao, G.(2007) *'Statistics for Agricultural Sciences'*, B.S. Publications, Narain, P. (1990). *'Statistical Genetics'*, Wiley Eastern, New Delhi
Hyderabad

Percus, J.K. (2001). *'Mathematics of Genome analysis'* , Cambridge University Press

Singh, R.K. and Chaudhary, B.D. 1985. *'Biometrical methods in quantitative Genetic analysis'* Kalyani Publishers, Ludhiana

Stansfield W.D.(1991). *'Theory and problems of Genetics'*, Scahum's Outline Series.

18. STAT 533 APPLIED LINEAR PROGRAMMING 1+1

Objective

The course is meant for students of Economics and others interested in optimization techniques under constraints to derive the desired output.

UNIT I

Classical Optimization Techniques: Necessary Conditions for an Extremum. Constrained Optimization: Lagrange Multipliers, Statistical Applications. Optimization and Inequalities. Classical Inequalities.

UNIT II

Numerical Methods of Optimization: Numerical Evaluation of Roots of Equations, Direct Search Methods, Sequential Search Methods – Fibonacci Search Method. Random Search Method, Simplex Search Method. Gradient Methods, like Newton's Method, and Method of Steepest Ascent..

UNIT III

Introduction to linear programming , approach, definition and basic theorems, Simplex method, Revised simplex method, Quality concepts, important theorems, Duality and Sensitivity Analysis. Integer Programming. Statistical Applications.

UNIT IV

Games and Linear Programming Elementary ideas of non linear programming – applications of linear programming in transportation problems . Nonlinear Regression and Other Statistical Algorithms, like Expectation – Maximization Algorithm.

Practical

Problems based on classical optimization techniques; Problems based on optimization techniques with constraints; Minimization problems using numerical methods; Linear programming (LP) problems through graphical method; LP problem by Simplex method;) LP problem using primal and dual method; Sensitivity analysis for LP problem; Problems based on Quadratic programming; Problems based on Integer programming;

Suggested Readings

Rustagi JS. 1994. *Optimization Techniques in Statistics*. Academic Press.

Taha HA. 2007. *Operations Research: Introduction with CD*. 8th Ed. Pearson Edu.

Zeleny M. 1974. *Linear Multiobjective Programming*. Springer.

19. STAT 534 TIME SERIES AND QUALITY CONTROL 2+1

Objective

This course is meant to teach the students the concepts involved in time series data analysis . Forecasting / projecting the future scenarios based on time series data can be studied. Statistical Quality Control and their applications in agribusiness and agro-processing industries.

Theory

UNIT I

Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis.

UNIT II

Linear stationary models: Autoregressive, Moving average and Mixed processes.

Linear non-stationary models: Autoregressive integrated moving average processes.

UNIT III

Forecasting: Minimum mean square forecasts and their properties, Calculating and updating forecasts.

UNIT IV

Introduction to Statistical Quality Control; Control Charts for Variables – Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups. Control charts- 'np', 'p' and 'c' charts.

UNIT V

Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection. Sampling inspection tables for selection of single and double sampling plans

Practical

Time series analysis, autocorrelations, correlogram and periodogram; Linear stationary model; Linear non-stationary model; Model identification and model estimation; Intervention analysis and outliers detection

Suggested Readings

Box G.E.P, Jenkins GM & Reinsel GC. 2007. *Time Series Analysis:Forecasting and Control*. 3rd Ed. Pearson Edu.

Brockwell PJ & Davis RA. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.

Chatterjee S, Hadi A & Price B.1999. *Regression* Analysis by Examples. John Wiley.

Cowden DJ. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.

Dodge HF & Romig HG. 1959. *Sampling Inspection Tables*. John Wiley.

Duncan A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.

Grant EL & Leavenworth RS. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.

Montgomery DC. 2005. *Introduction to Statistical Quality Control*. 5th Ed. John Wiley.

Montgomery DC & Johnson LA. 1976. *Forecasting and Time Series Analysis*. McGraw Hill.

Shumway RH & Stoffer DS. 2006. *Time Series Analysis and its Applications: With R Example*

Wetherhil G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press

20. STAT 536 NON PARAMETRIC METHODS 2+0

Objective

This course is meant for training of the Social science / Home Science students dealing mainly with different types of qualitative data based on nominal, ordinal etc. scales. This course would enable the students on various analytical methods of such data.

UNIT I

Levels of measurements and the statistic appropriate to each level. Parametric and non parametric statistical tests , Binomial test, Chi- square test, Kolmogorov- Smirnov one sample test, Run test

UNIT II

Sign test, Wilcoxon's matched pair, Signed rank test, Fishers exact test, Median test, Mann- Whiteney's U test, Kolmogorov – Smirnov two sample test.

UNIT III

K- related samples, Cochran's Q test, Friedmen's two way analysis of variance, Kruskel Wallis test.

UNIT IV

Measures of correlation, Spearman's rank correlation, Kendall's rank correlation, Kendalls partial rank correlation and coefficient of concordance.

Suggested Readings

Conover, W.J.(1999) *Practical Non parametric Statistics*, John Wiley

Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley

Sidney Siegal *et al* (1980) Non parametric Statistics for behavioral Sciences, 2nd Ed. Mcgraw Hill

3. Remedial/ supporting courses in Mathematics and Statistics for Agrl. Graduates admitted to M.Sc.(Agricultural Statistics).

1. STAT 537 CALCULUS 2+0

Differentiation-successive differentiation-maxima and Minima points of inflexion-curvature-Taylor's theorem-Maclaurin's theorem-mean value theorem-Rolle's theorem-Integration – standard forms – integration by substitution and by parts-Differential equations – standard forms variable separable – homogeneous, linear, Bernoulli's and Clairaut's forms, linear equations with constant coefficients. Integrating factors and exact equations.

2. STAT 538 ANALYTICAL GEOMETRY 2+0

Rectangular co-ordinates, distance between two points, area of triangle, equations to a straight line, angle between two lines, standard equations of ellipse, parabola and hyperbola, their tangents, normals, polar of a point. Chords with given mid point. Pairs of tangents from a given point, conjugate lines and diameters.

3. STAT 539 MODERN ALGEBRA 1+0

Sequence spaces, linear dependence, linear mappings, bilinear mappings, linear transforms, binary operations, one-to-one correspondence and isomorphism, group and sub groups, permutation groups, even and odd permutations, complexes and cosets, normal subgroups, homomorphism, rings, sub rings, ideals, zero divisors-fields.

4. STAT 540 MATRIX ALGEBRA 2+0

Definition of matrices, matrices associated with a given matrix – transpose, conjugate and conjugate transpose, different types of matrices, sub-matrices, determinant of a square matrix, minor of a matrix, scalar multiple of matrix, sum, difference and product of matrices, associative and distributive laws of matrices, adjoint of a square matrix inverse of square matrix, rank of a matrix, solution of linear, homogeneous equations by matrices, characteristic matrix and characteristic equation of a matrix, Cayley-Hamilton theorem, Eigen values and Eigen vectors, orthogonal matrices, quadratic forms – Canontical forms, index of a quadratic from, definite, semi-definite and indefinite real quadratic forms, Gram matrices.

STAT 541 TRIGONOMETRY 1+0

Measurement of angles-sexagesimal and contesimal system-Radian-Length of arc-circular co-ordinates-unit circle-Trigonometric ratios of an acute angle-Circular functions of a real number 't' Trigonometric functions of angles of any magnitude-Polar co-ordinates, periodicity and graph of trigonometric functions addition and product formulae-Geometrical proof of Cos (A-B) etc. Multiple and sub multiple angles-Geometrical derivation of Sin 180 and Cos 360-Inverse trigonometric functions-Principal values of inverse functions-Trigonometric equations-equations involving inverse trigonometric function-graphical solution of equations- Properties of triangles-incircles and excircles-Solution of triangles- Heights and distances.

STAT 542 PROBABILITY THEORY 2+0

Definition of probability – events – addition and multiplication theorems – conditional probability–distribution of a single random variable, continuous and discontinuous distributions-Joint distributions, marginal and conditional distributions. Mathematical

expectation, moments, cumulants, moment generating functions, Binomial poison and Normal distribution and their fittings-Statistical models for observational data – free hand fitting methods of least squares, linear model, correlation and regression, quadratic model, multiple regression model, partial and multiple correlation.

STAT 543 MATHEMATICS 2+0

Limits of a function, Derivative of sum, product and function of a function, application of differentiation in Economics-Partial differentiation, constrained optimization, optimization with single variable input-Successive differentiation, Maxima and minima of more than one independent variable- Integration–integration by parts, definite integrals, double and multiple integrals-Differential equation, solution of linear homogeneous equations, solution of second order equations – its application-Algorithms, errors and approximations, simple methods of interpolation – Newton's, Stirling's, Bessel's, Legrange's and Gauss' methods-Graphs and solutions of equations, method of false position, Newton-Raphson method, numerical integration – Trapezoidal, Simpson's one-third and three-eighth rules- Matrices and determinants, rank of a matrix, inverse of a square matrix, orthogonal matrices, Cayley-Hamilton theorem-Eigen values and Eigen vectors.

STAT 544 BASIC STATISTICS 2+0

Definition of Statistics, Classification and tabulation of data, frequency distribution, Diagrammatic and graphic representation of data. Measures of central tendency, Measures of dispersion, Skewness and Kurtosis. Elementary ideas on probability, Probability distributions- Binomial, Poisson, Normal distributions. Associated measurements, Scatter diagram, Correlation and linear regression .Rank correlation coefficient and coefficient of concordance. Elementary ideas in sampling, advantages of sampling. Sampling and non-sampling errors. Simple Random Sampling-with and without replacement. Estimation of parameters. Cluster sampling, Systematic sampling, Stratified sampling, multistage stratified random sampling and its applications.

***Suggested Readings**

Frank Ayres (1984). Schaum's outline Series. Theory and Problems of Matrices, Mcgraw Hill

Rao, C.R (1965)., Linear Statistical Inference and its applications. Second edition. Wiley Eastern Ltd.

Damodar N Gujarathi.(1995). Basic econometrics, Mcgraw – Hill, New Delhi

Finney, D.J.(1964). Statistical Methods In Biological Assays. 2nd edition. Griffin London.

Das, M.N and Giri, V.V (2003)., Design and Analysis of Experiments.,New Age International(p) Ltd.

Narain, P.(1990).Statistical Genetics. Wiley Eastern Ltd., New Delhi.

Chatfield, C & Collins A.J. Introduction to Multivariate Analysis.

PGS 506 CROP PRODUCTION: CONCEPTS AND PRACTICES 2+1

(Compulsory for non-agriculture graduates of Master's programme)

Objective

To impart theoretical and practical knowledge about crop production under different agro-ecological conditions.

Theory

UNIT I

Agriculture and its role in national development, food security; General features of climate - India; Crop environment, weather and significance of various weather elements; Crop production - definition and scope, crop classification based on season,

life cycle, taxonomy and economic use; Growth and yield of crops, growth parameters, yield attributes and factors affecting them; Thermal and photo response of plants, thermal indices and growing degree day concept in crop phenology.

UNIT II

Quality of good seed, ideal condition for germination, seed treatment, hybrid and composite seeds, categories of seeds (certified, foundation and breeder seed); Importance of sowing time, seed rate, sowing methods, plant population; Tillage and intercultural operations - objectives and methods; Weeds in crop production; Irrigation - scheduling, methods and water use efficiency; Harvesting, threshing, winnowing, storage and processing.

UNIT III

Crop rotations, mixed cropping, inter cropping, its objectives and importance; Definitions of monocropping, double cropping, multiple/intensive cropping, relay cropping with example in brief; Farming system and sustainable agriculture.

UNIT IV

Rainfed agriculture and dry farming, soil moisture conservation; Agronomic techniques to improve crop yields and watershed management.

UNIT V

Soil as a three phase disperse system, its physical chemical and biological properties; Soil fertility and soil productivity, manures and fertilizers, integrated nutrient management; Soil and water testing: objectives, sampling techniques, interpretation of results and recommendations; Selection of soil, and management of water and nutrients in pot culture experiments; Problem soils and their management; Soil and water pollution.

UNIT VI

Classification of vegetable crops; Types of vegetable farming; Principles of vegetable production; Raising of vegetable seedlings under different environmental conditions; Important practices of cool and warm season vegetable crops.

UNIT VII

Concepts in Horticulture - methods of propagation, systems of planting and layout, training and pruning, fruit growth and development, fruit maturity and ripening; Post harvest management of fruits and flowers; Production technology of fruit and flower crops.

Practical

Identification of seeds of different crops, germination test and seed rate calculations; Visit to farm for identification of different crop plants and measurement of growth; Herbicide formulations, delivery systems; Field layout of different sowing methods. Sampling, processing, storage and analysis of soil samples for available

nutrients (N, P, K, S, Fe, Zn, Mn and Cu); Sampling, processing, storage and analysis of plant samples for N, P, K, S, Fe, Zn, Mn and Cu content. Raising nursery in field and protected conditions; Practices in methods of propagation; Various methods of training system and pruning, system of planting; Post harvest processing

List of Journals

- American Statistician
- Annals of Institute of Statistical Mathematics
- Annals of Statistics
- Australian and New Zealand Journal of Statistics
- Biometrical Journal
- Biometrics
- Biometrika
- Bulletin of Calcutta Statistical Association

• Canadian Journal of Statistics
• Communication in Statistics (Simulation & Computation)
• Communication in Statistics (Theory & and Methods)
• Experimental Agriculture
• Institute of Mathematical Statistics Bulletin (IMSB)
• Journal of American Statistical Association
• Journal of Applied Statistics
• Journal of the Indian Society of Agricultural Statistics
• Journal of the International Statistical Review
• Journal of Statistical Planning and Inference
• Journal of Statistical Theory and Practice
• Journal of Statistics, Computer and Applications
• Journal of Royal Statistical Society, Series A
• Journal of Royal Statistical Society, Series B
• Journal of Royal Statistical Society, Series C
• Metrika
• Metron
• Scandinavian Journal of Statistics (Theory & Applied)
• Sankhya
• Statistica
• Statistical Science
• Statistics and Probability Letters
• Technometrics

Computer Application

• ACM Transactions on Knowledge Discovery from Data
• Applied Intelligence - The International Journal of Artificial Intelligence, Neural Networks, and Complex Problem-Solving Technologies
• Computational Statistics & Data Analysis, Elsevier Inc.
• Computers and Electronics in Agriculture, Elsevier Inc.
• Data Mining and Knowledge Discovery: An International Journal (DMKD)
• Expert Systems with Applications, Elsevier Inc.
• IEEE Transactions on Knowledge and Data Engineering
• IEEE Transactions on Neural Networks
• IEEE Transactions on Pattern Analysis and Machine Intelligence
• International Journal of Computing and Information Sciences
• International Journal of Information and Management Sciences
• International Journal of Information Technology
• Journal of Artificial Intelligence Research
• Journal of Combinatorics, Information and System Sciences
• Journal of Computer Sciences and Technology
• Journal of Computer Society of India
• Journal of Indian Society of Agricultural Statistics
• Journal of Intelligent Information Systems - Integrating Artificial Intelligence and Database Technologies
• Journal of Machine Learning Research
• Journal of Statistics, Computer and Applications
• Journal of Systems and Software
• Journal of Theoretical and Applied Information Technology
• Knowledge and Information Systems: An International Journal (KAIS)
• Lecture Notes in Computer Science, Springer Verlag.
• Machine Learning

• Transactions on Rough Set

e-Resources

• Design Resources Server. *Indian Agricultural Statistics Research Institute(ICAR), New Delhi 110 012, India*. www.iasri.res.in/design.
• Design Resources: www.designtheory.org
• Free Encyclopedia on Design of Experiments
• http://en.wikipedia.org/wiki/Design_of_experiments
• Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
• Electronic Statistics Text Book: http://www.statsoft.com/textbook/stathome.html.
• Hadamard Matrices http://www.research.att.com/~njas/hadamard;
• Hadamard Matrices http://www.uow.edu.au/~jennie/WILLIAMSON/williamson.html.
• Course on Experimental design: http://www.stat.sc.edu/~grego/courses/stat706/.
• Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
• Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
• Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
• Statistical Calculators: http://www.graphpad.com/quickcalcs/index.cfm
• SAS Online Doc 9.1.3: http://support.sas.com/onlinedoc/913/docMainpage.jsp

Suggested Broad Topics for Research

• Design and analysis of multi-response experiments
• Design and analysis of micro-array experiments
• Design and analysis of experiments for precision agriculture
• Design and analysis of agroforestry experiments
• Bayesian designing of experiments, Bayesian optimality and Bayesian analysis of experimental data
• Computer aided search of efficient experimental designs for various experimental settings
• Fractional factorials including search designs, supersaturated designs, computer experiments, etc.
• Statistical techniques in bioinformatics, biotechnology, microbiology, genomics, etc.
• Optimality aspects and robustness of designs against several disturbances under various experimental settings (single factor, multi-factor, nested classifications, etc.)
• Small area estimation
• Computer intensive techniques in sample surveys
• Analysis of survey data, regression analysis, categorical data analysis, analysis of complex survey data
• Assessment and impact survey methodologies, valuation of natural resources, its degradation, depletion, etc.
• Linear and non-linear modeling of biological and economical phenomena
• Non-linear time series modeling
• Non-linear stochastic modeling
• Forecast models for both temporal and spatial data
• Innovative applications of resampling techniques
• Applications of remote sensing, GIS, ANN etc. in modeling various phenomena
• Econometric models for risk, uncertainty, insurance, market analysis, technical efficiency, policy planning, etc.
• Statistical studies on value addition to crop produce

XVI FOOD SCIENCE AND NUTRITION

COURSE STRUCTURE – AT A GLANCE

CODE	COURSE TITLE	CREDITS
FN 501*	ADVANCED FOOD SCIENCE	2+1
FN 502 *	ADVANCED NUTRITION	2+1
FN 503 [I]	FOOD ANALYSIS	1+2
FN 504*	ADVANCES IN COMMUNITY NUTRITION	2+1
FN 505	FOOD PRESERVATION AND PROCESSING TECHNOLOGY	2+1
FN 506	CLINICAL NUTRITION	2+1
FN 507	NUTRITION DURING LIFE CYCLE	3+0
FN 508	NUTRITION AND PHYSICAL FITNESS	2+1
FN 509*	ADVANCED DIET THERAPY	2+1
FN 510	FOOD TOXICOLOGY	2+0
FN 511	ADVANCED HUMAN PHYSIOLOGY	2+1
FN 512	FOOD SERVICE MANAGEMENT	1+2
FN 513	FOOD PRODUCT DEVELOPMENT	1+1
FN 514	NUTRITION AND IMMUNITY	2+0
FN 591	MASTER'S SEMINAR	0+1
FN 599	MASTER'S RESEARCH	20
FN 515***	FOOD AND NUTRITION	2+0
FN 601**	ADVANCES IN CARBOHYDRATES, PROTEINS AND LIPIDS	3+1
FN 602**	ADVANCES IN VITAMINS AND HORMONES	2+0
FN 603**	MINERALS IN HUMAN NUTRITION	2+1
FN 604	ADVANCES IN FOOD SCIENCE AND TECHNOLOGY	2+1
FN 605	ADVANCES IN ENERGY METABOLISM	2+0
FN 606 [I]	NUTRITION AND AGRICULTURAL INTERFACE	3+0
FN 607	NUTRITION IN EMERGENCIES	2+0
FN 608 [I]	APPLICATION OF BIOTECHNOLOGY IN FOOD SCIENCE AND NUTRITION	1+1
FN 609	GLOBAL NUTRITIONAL PROBLEMS	2+0
FN 610	MATERNAL AND CHILD NUTRITION	2+1
FN 691	DOCTORAL SEMINAR I	0+1
FN 692	DOCTORAL SEMINAR II	0+1
FN 699	DOCTORAL RESEARCH	45

*** Compulsory for Master's Programme**
**** Compulsory for Ph.D Programme**
***** Remedial Courses for Agricultural Statistcs**
[I] Interdisciplinary course

1.FN 501 ADVANCED FOOD SCIENCE 2+1

Objective

To make the students aware about common food processing techniques and understand the physico-chemical properties of foods.

Theory

UNIT I

Classification of organic compounds, Colloidal chemistry as related to foods; evaluation of food by subjectiveand Objective methods.Principles of cooking, culinary qualities and uses of cereals. Starch cookery. Carbohydrates in foods sources and characteristics of sugar, starch, cellulose, pectin and gums characteristics in foods; effect of cooking and processing techniques.

UNIT II

Protein in foods: Plant and animal foods;Structure, principles of cookery , chemical and physical properties, effect of cooking and processing techniques of pulses, roots and tubers and nuts and oil seeds. Chemical and physical properties, effect of cooking and processing techniqueshemical changes of fats and oils during heating and other processing and storage

UNIT III

Classification, importance, composition of fruits and vegetables and effect of cooking and other processing on their nutritive value. .Nutritional composition,structure, Prinples of cookery, culinary properties and uses of meat ,poultry, fish and egg.

UNIT IV

Classification and importance of beverages; food pigments; browning reaction. Definition, classification, uses and legal aspects of food additives; Enrichment and fortification , malting and germination of foods, losses during handling and storage of foods.Classification, nature and uses of leavening units.

Practical

Microscopic structure of different starch granules; evaluation of food by subjective and objective methods ; changes in colour , texture and flavour of foods due to processing; effect of cooking on protein , fat and carbohydrates ; product preparation using leavening agents; preparation of foams and emulsions, project work related to text .

Suggested Readings

Borgstrom G.1968. *Principles of Food Science*. Vols. I, II. Macmillan.

Desrosier NW & Desrosier JN. 1997. *The Technology of Food Preservation.* AVI Publ.

Griswold RM. 1962. *The Experimental Study of Foods*. Houghton Miffin.

Khader V. 1999 *Text Book on Food Storage and Preservation*. Kalyani.

Krishna Swami K. 2000 *Nutrition Research – Current Scenario*. Oxford & IBH.

Lowe B. 1955 *Experimental Cookery*. John Wiley & Sons.

Manay NS & Shadaksharaswamy M. 1997. *Foods, Facts and Principles*. New Age International.

McWilliams M. 1993. *Foods, Experimental Perspectives*. Macmillan.

Meyer LH. 1976 *Food Chemistry*. AVI Publ.

Potter NN & Hotchkiss HJ. 1996. *Food Science*. CBS.

Subbulakshmi G & Udipi SA. 2006. *Food Processing and Preservation*. New Age International.

2.FN 502 ADVANCED NUTRITION 2+1

Objective

To enable the students to understand the current trends in nutrition, functions, deficiencies and toxicity of different nutrients and acquaint about nutritional requirement in special conditions.

Theory

UNIT I

Functions, sources, requirements, Metabolism of carbohydrates; definition, composition, classification, functions and role of dietary fibre in various physiological disorders.

UNIT II

Basis of requirement, functions, sources, Metabolism of protein; Methods of assessing protein quality .Basis of requirement,functions, sources, metabolism and deficiency disorders of lipids;essential fatty acids and eicosanoids.

UNIT III

Energy, BMR- Total energy- Nutrition and work capacity- sports nutrition- Space nutrition. Requirements, functions, sources, deficiencies and toxicities of fat and water soluble vitamins

UNIT IV

Requirement, functions, sources, deficiency, toxicity and factors affecting absorption and utilization of macro and micro minerals .Water balance; acid and base balance.

Practicals

Estimation of proximate principles in foods.

Suggested Readings

Anderson L, Dibble, Turkki PR, Mitchell HS & Rynbergen HJ. 1982. *Nutrition in Health and Disease*. JB Lippincott.

Bamji MS, Rao NP & Reddy V. 1999. *Text Book of Human Nutrition*.Oxford & IBH.

FAO/WHO/UNU 1985. *Energy and Protein Requirement*. Tech. Report 7824, WHO.

Guthrie HA. 1989. *Introductory Nutrition*. Times Mirror/Mosby CollegePubl. ICMR. 1990. *Nutrient Requirement and Recommended Dietary Allowance for Indians*. A Report of Expert Group of the ICMR, NIN, Hyderabad.

James WPT & Schofied EC. 1990. *Human Energy Requirements – A Manual for Planners and Nutritionists*. Oxford University Press.

Jellifee DB. 1966. *The Assessment of the Nutrition Status of the Community*. WHO.

Jolliffe N. 1962. *Clinical Nutrition*. Hoeber Medicalk Division.

Khader V, Sumathi S & Manorama R. 1998. Course Manual of the Short Course on *"Recent Advances in Vitaminology"*, Center for Advanced Studies, Department of Foods and Nutrition, Post Graduate and Research Centre ANGRAU, Hyderabad.

Packer L & Funchs J. 1997. *Vitamin C in Health and Disease*, Marcel Dekker.

Passmore R & Eastwood MA. 1986. *Human Nutrition and Dietetics*. Elbs Churchill.

Pike RL & Brown ML. 1988 *Nutrition - An Integrated Approach*. John Wiley & Sons.

Proceedings of the Nutrition Society of India, NIN, Hyderabad.

Robinson CH & Lawler MR. 1986. *Normal and Therapeutic Nutrition*. Macmillan.

Shills ME, Olson JA, Shike M & Ross AC. 1999 *Modern Nutrition inHealth and Disease*. Williams & Wilkins.

Swaminathan MS. 1985. *Advanced Text Book on Food and Nutrition* Vols. I, II. The Bangalore Printing & Publ. Co.

3.FN 503 FOOD ANALYSIS 1+2

Objective

To acquaint the students with principles, techniques and application of different methods of analysis for various nutrients. .

Theory

UNIT I

Familiarization to terms and calculations used in preparation of various standard solutions. Sample and sampling techniques.

UNIT II

Principles, techniques and applications of colorimetric, spectrophotometer and atomic absorption spectrophotometer.

UNIT III

Principles, techniques and applications of spectrophotometer fluorimetry, flame photometry and electrophoresis.

UNIT IV

Principles techniques and application of chromatography (paper chromatography, TLC,GLC, HPLC). Introduction to animal assay.

Practical

Handling of equipment and instruments; preparation of samples, solutions and buffers; quantitative estimation of proximate principles, minerals and vitamins by use of colorimetry, flame photometry, UV spectrophotometer; chromatography, atomic absorption spectrophotometer and photofluorometry, analysis of antinutritional factors; estimation of protein and starch digestibility; fractionation of protein; food adulteration tests. Tannins, pigments in foods.

Suggested Readings

AOAC 1995. *Association of Official Analytical Chemists*. Washington, DC.

Gruenwedels DW & Whitakor JR 1984. *Food Analysis: Principles and Techniques.* Vols. I-VIII. Marcel Dekker.

Joslyn MA. 1970. *Methods in Food Analysis: Physical, Chemical and Instrumental Methods of Analysis.* Academic Press.

Pomeranz Y & Molean CE. 1977. *Food Analysis Theory and Practice*. AVI Publ.

Sawhney SK & Singh R. 2000. *Introductory Practical Biochemistry*. Narosa.

4.FN 504 ADVANCES IN COMMUNITY NUTRITION 2+1

Objective

To enable the students to understand the nutritional problems of the community and gain skills in planning, executing and evaluating nutrition projects of the community.

Theory

UNIT I

Assessment of the nutritional status at individual, household and institutional level: direct and indirect methods.

UNIT II

Ecological, socio-cultural, economic and demographic correlations of malnutrition; prevalence, etiology, biochemical and metabolic changes in PEM and other micro nutrient deficienes .

UNIT III

Major nutritional problems of the state, nation and world. Food and Nutrition security of the country. Nutrition intervention- Definition, importance, methods of nutrition intervention and their impact evaluation.

UNIT IV

National nutritional programmes and policies; nutritional surveillance. National programmes and policies regarding food production and distribution.

Practical

Market survey for food availability and their cost; development of low cost nutritious recipes suitable for various vulnerable groups; visit to the ongoing public health nutrition programme and report writing; Techniques of assessment of nutritional status.

Project Work:- Studying existing diet and nutrition practices, planning and conducting survey, analyzing data and writing report; development, implementation and evaluation of community nutrition and health programmes.

Suggested Readings

Gopaldas T & Seshadari S. 1987. *Nutrition Monitoring and Assessment.* Oxford University Press.

Jeannette B Endres. 1990 *Community Nutrition Challenges and Opportunities*. Merrill.

Jelliffe DB. 1966. *The Assessment of the Nutritional Status of the Community*. WHO.

Jolliffee N.1962. *Clinical Nutrition*. Hoeber Medical Division.

McLaren DS.1977. *Nutrition in the Community*. John Wiley & Sons.

Nutrition Foundation of India Bulletin. New Delhi.

Nutrition News. NIN, Hyderabad .

Park JE & Park K. 2000. *Text Book of Preventive and Social Medicine*. Banarsidas Bhanot Publ.

Rao BSN, Deosthale YG & Pant KC.1998 (Revised and updated). *Nutritive Value of Indian Foods* by Gopalan C, Ramashastri BV & Balasubramanium SC. NIN, Hyderabad.

Shukla PK. 1982. *Nutritional Problems of India*. Prentice Hall of India.

5. FN 505 FOOD PRESERVATION AND PROCESSINGTECHNOLOGY 2+1

Objective

To know preservation and processing technology of various food stuffs, physical and chemical principles in food processing and ways of quality control, waste disposal and sanitation in food industries.

Theory

UNIT I

Importance and significance of food preservation, food spoilage causes and effects, principles underlying food preservation and processing operations including thermal, radiation, refrigeration, freezing and dehydration. Effect of processing on physicochemical characteristics.

UNIT II

Processing technology for preservation and production of variety food products using plant and animal foods- cereals legumes ,oil seeds- losses during storage, handling and processing

UNIT III

Techniqes for processing and preservation of vegetables and fruits- production of variety fruit products- losses during storage , handling and processing. FPO specifications, requirements for establishing fruits and vegetables preservation units. Processing technology for milk and milk products, egg, meat, poultry and fish, convenience foods. Technologies underlying in mutual supplementation, enrichment and fortification. Food additives commonly used in food industries.

UNIT IV

Quality control in food industry: raw material , finished products. Waste management and sanitation in food industries. Packaging of foods. Storage and marketing of processed foods.

Practicals

Processing and preservation of various foods , market survey on processed foods. vist to processing units/ industries

Suggested Readings

Desrosier NW & Desrosier JN. 1977. *The Technology of Food Preservation*. AVI Publ.
Frank AP. 1987. *Modern Processing, Packaging and Distribution System for Foods*. AVI Van nonstand Reinhold Co.
Frazier WC. 1988. *Food Microbiology*. Tata McGraw Hill.
McWilliams M. 1993. *Foods - Experimental Perspectives*. Macmillan.
Potty VH & Mulky MJ. 1993. *Food Processing*. Oxford & IBH.
Srilakshmi B. 2001. *Food Science*. New Age International.
Swaminathan MS. 1993. *Food Science and Experimental Foods*. Ganesh & Co.

6. FN 506 CLINICAL NUTRITION 2+1

Objective

To familiarize students about estimation of RDA, deficiency of nutrients, estimation of different nutrients and metabolites in normal and diseased conditions.

Theory

UNIT I

Methods for estimating requirements and recommended allowances of energy, protein, minerals and vitamins for different age groups and physiological states.

UNIT II

Nutrient interrelationship; historical background, epidemiology, preventive and therapeutic measures of protein energy malnutrition.

UNIT III

Interrelationship, etiology and preventive measures of vitamin and mineral deficiencies toxicities.

UNIT IV

Principles and interpretation of clinical laboratory methods with particular emphasis on their interpretation relative to nutritional status and disease; interaction between nutrients, infections and drugs.

Practical

Biochemical analysis of blood and urine under normal and diseased conditions for specific metabolites

Suggested Readings

Anderson L, Dibble MV, Turkki PR, Mitchel HS & Rynbergen H. 1982.*Nutrition in Health and Disease*. JB Lippincott Co.
ICMR 1998. *Recommended Dietary Allowance for Indians*. ICMR.
Khanna K, Gupta S, Seth R & Puri S. 1997. *Text Book of Nutrition and Dietetics*. Phoenix Publ.
Oser H. 1969. *Physiological Chemistry*. Tata McGraw Hill.
Raghuramalu N, Nair KM & Kali Sundram S. 1983. *A Manual of Laboratory Techniques*. NIN Hyderabad.
Srilakshmi B. 2002. *Nutrition Science*. New Age International.
Swaminathan M.1988. *Principles of Nutrition and Dietetics*. BAPPCO.

7. FN 507 NUTRITON DURING LIFE CYCLE 3+0

Objective

To enable the students to know physiological changes and nutritional requirements during various stages of life cycle.

Theory

UNIT I

Adulthood: sex, occupation, income. Pregnancy: physiological changes in pregnancy, weight gain during pregnancy, food and nutrient requirements, storage of nutrients during pregnancy and impact of good nutrition on the outcome of pregnancy, complications of pregnancy and their nutritional management. Lactation: Physiology of lactation, impact of nutrition on efficiency and milk production, food and nutrient requirements during lactation.

UNIT II

Infancy: role of nutrition on physical and mental development, rate of growth - weight as an indicator, assessment of growth, nutrient requirement during infancy, feeding of infants – value of breast feeding, breast milk composition, breast feeding Vs artificial feeding, types of milk and their use in infant feeding, methods of formula preparation, weaning and supplementary foods, weaning practices in the community, special nutritional concern in infant feeding, feeding the premature and low birth weight infants. Nutritional disorders and common ailments in infancy, feeding the sick child, immunization schedule and growth charts.

UNIT III

Preschool age: growth and development – Physical and mental, prevalence of malnutrition in preschool years and food habits, nutritional requirements during preschool year and supplementary foods. School age: growth and development, nutritional requirements of school age children, specific problems in feeding school children.

UNIT IV

Adolescence: physical and physiological changes, nutritional requirements of adolescents, food preferences and nutritional problems. - Nutritionals problems of middle aged women and Elderly - physical and physiological changes, nutritional requirement, nutrients influencing aging process.

Suggested Readings

Anderson L, Dibble MV, Turkki PR, Mitchell HS & Rynbergen HJ. 1982. *Nutrition in Health and Disease*. JB Lippincott Co.

Beal VA. 1980. *Nutrition in the Life Span*. John Wiley & Sons.

Falkner F & Tanner JM. 1978. *Human Growth.* Vols. I-III. Plenum Press.

FAO/WHO/UNU. 1985. *Energy and Protein Requirement*. Tech. Report 724. WHO.

Ghosh S. 1988. *The Feeding and Care of Infant and Young Children*.
Voluntary Health Association of India, New Delhi.

Guthrie HA. 1989. *Introductory Nutrition*. Times Mirror/Mosby College Publ.

ICMR. 1990. *Nutrient Requirement and Recommended Dietary Allowance for Indians*. A Report of Expert Group of the ICMR, NIN, Hyderabad.

Khetarpaul N, Katyal Sudha K & Grover I. 2001 *Infant Health and Nutrition*. Agro Tech. Publ. Academy.

Krause MV & Mahan LK. 1990. *Food, Nutrition and Diet Therapy*. WB Saunders.

Robinson CH & Lawler MR. 1986. *Normal and Therapeutic Nutrition*, McMillan.

Williams SR, Worthington RS, Sneholinka ED, Pipes P, Ress JM & Mahal KL. 1988. *Introduction Nutrition throughout the Life Cycle*. Times Mirroe/Mosby College Publ.

8. FN 508 NUTRITION AND PHYSICAL FITNESS 2+1

Objective

To enable the students to know the recent techniques of body composition and energy metabolism for the assessment of nutritional status.

Theory

UNIT I

Overview of nutritional management vis-a-vis physical fitness, body composition and physical fitness.

UNIT II

Methods of measuring body composition: direct and indirect. Body composition in different physiological conditions and factors affecting it.

UNIT III

Energy metabolism and physical fitness: concept, importance, influencing factors.

UNIT IV

Techniques to measure energy expenditure and energy intake. Techniques to assess physical fitness. Aging theories, physiology, mechanism and role of nutrients in arresting aging process.

Practical

Project relevant to text: selection of topic, planning of project, development and standardization of tool, collection of data, analysis of data, report writing.

Suggested Readings

Falkner F & Tanner JM. 1978. *Human Growth - Principles and Prenatal Growth.* Vol. I. Bailliere Tindall.

Falkner F & Tarnner JM. 1980. *Human Growth Methodology*. *Ecological,Genetic, and Nutritional Effects on Growth.* Vol. III. Plenum Press.

Passmore R & Eastwood MA. 1986. *Human Nutrition and Dietetics*. ELBS Churchill Livngstone.

Pike RL & Brown ML. 1988. *Nutrition - An Integrated Approach*. John Wiley & Sons.

9.FN 509 ADVANCED DIET THERAPY 2+1

Objective

To familiarize the students with newer concepts in dietary management of various disorders and diseases.

Theory

UNIT I

Role of dietician in a health care team in hospital and community. Therapeutic adaptation of normal diets. Hospital diets, methods of feeding patients . Pre and post operative diets. Dietary management of various nutritional disorders and disease conditions, fevers and infections.

UNIT II

Dietary management during burns, allergy, gastrointestinal and liver diseases.

UNIT III

Dietary management of cardiovascular diseases, renal disorders and obesity.

UNIT IV

Dietary management of diabetes, cancer and HIV. Nutrition in critical care.

Practical

Formulation of food exchanges. Therapeutic modifications of diet in terms of nutrients, consistency and composition for various disorders and diseases. Visits to hospitals.

Suggested Readings

Robinson, Lawler, Chenoweth & Garwick, 1987. *Normal & Therapeutic Nutrition.* 17th Ed. Macmillan Publishing Co.

Shills ME & Young VR. *Modern Nutrition in Health & Disease* 7th Ed. Lea & Febiger.

Stanfield PS, Hui YH & American Dietetics Association 1992. *Nutrition & Diet Therapy*. 2nd Ed. Jones & Bartlett Publ.

10.FN 510 FOOD TOXICOLOGY 2+0

Objective

To enable the students to understand the toxic substances present in the foods and processing techniques for removal of toxins from foods.

Theory

UNIT I

Introduction and significance of food toxicology. Food poisoning: types, causative factors, preventive symptoms, natural food toxins, antinutritional factors, other food toxins, harmful effects, methods of removal.

UNIT II

Microbial toxins and food intoxications. Source of contamination Effect on health, preventive measures, methods of inactivation/destruction.

UNIT III

Chemical toxins: Pesticides, insecticides metallic and others, residual effects, preventive measures, methods of removal.

UNIT IV

Food packaging material, potential contaminants from food packaging material. Food laws and standards: FPO, ISI, Ag Mark, Codex Alimentarius, ISO, mark for vegetarian and non vegetarian foods, ecofriendly products and others in operation.

Suggested Readings

Ayres JC. 1968. *The Safety of Foods.* AVI Publ.

Hayes WJ. 1975. *Toxicology of Pesticide.* The Willams & Wilkins Co.

Jacob T. 1976. *Food Adulteration.* Sib Wasani Macmillan Co.

Swaminathan MS. 1985. *Advanced Text Book on Food and Nutrition.* Vol II. The Bangalore Printing & Publ. Co.

11.FN 511 ADVANCED HUMAN PHYSIOLOGY 2+1

Objective

To enable the students to understand the anatomy and functions of human body and techniques/methods of blood and urine analysis.

Theory

UNIT I

Reticulo- endothelial system: functions, classification. Lymphatic system: functions, circulation. Circulatory System: blood - composition blood cells - development and function of blood cells, blood clotting, blood grouping and hemoglobin, Heart: anatomy, cardiac cycle, blood pressure and factors affecting blood pressure.

UNIT II

Respiratory system: anatomy, physiology and mechanism of respiration, regulation of respiration. Digestive system: anatomy of gastrointestinal tract and accessory organs. Digestion and absorption of food, regulation of appetite.

UNIT III

Excretory system: anatomy and functions of kidney, formation, composition and excretion of urine. Endocrine glands, mode of action of hormones.

UNIT IV

Reproductive system: structure and functions of male and female reproductive organs. Nervous system: anatomy and functions, Musculo skeletal system:anatomy and functions.

Practical

Estimation of hemoglobin. Identification of blood groups. Preparation of blood slide, identification and counting of blood cells. Haematocrit and sedimentation rate. Measurement of blood pressure.

Suggested Readings

Best CH & Taylor NB. 1989. *The Human Body. ASI Publ. House.* (Source: National Book Depot, Bombay).

Chatterjee CC. 1992. *Human Physiology.* Vols. I , II. Medical Allied agency

Guyton AC. 1991. *Text Book of Medical Physiology.* WB Saunders.

Mukherjee KL. 1994. *Medical Laboratory Technology.* Vol I. Tata McGraw Hill.

Wilson KJW & Ross JS.1987. *Ross and Wilson Anatomy and Physiology in Health and Illness.* 6th Ed. Churchill Livingstone.

12. FN 512 FOOD SERVICE MANAGEMENT 1+2

Objective

To enable the students to understand the process of planning, organizing and controlling the management of food and other resources in institutions.

Theory

UNIT I

Types of food services. Organization: Definition, types. Management: tools of management.

UNIT II

Personnel management. Books, records and record keeping. Cost control in food services. Menu planning.

UNIT III

Meal services management: types of services. Quantity food production: Principles involved in development of recipes in large scale cooking, Standardization of recipes, Utilization of left over foods.

UNIT IV

Planning of layout and equipment for foods services. Sanitation and hygiene in handling foods.Personnel hygiene and its importance.

Practical

Standardization of recipes: planning and preparation , modification in basic recipe, preparation of standard recipe. Use of left over foods. Visit to different types of food service institutions and study the following: Organization, physical plan and layout, food service equipment, sanitation and hygiene. Practical experience in organization and management of a college cafeteria/ hotels.

Suggested Readings

Fuller J. 1966. *Chefs Manual and a Kitchen Management.* B.T. Badtsford Ltd.
Kazarian EA. 1975. *Food Service Facilities - Planning,* AVI Publ.
Kotschevar LH. 1961. *Food Service, Layout and Equipment Planning.*John Wiley & Sons.
Sethi M & Malhan S. 1997. *Catering Management - An Integral Approach.*New Age Internationl.
Treat N & Richards 1997. *Quantity Cookery*. Little Brown & Co.
West BB, Wood L, Harger VF & Shugart GS. 1977. *Food Service inInstitutions,* John Wiley & Sons.

13. FN 513 FOOD PRODUCT DEVELOPMENT 1+1

Objective

To enable the students to understand the concept of product development, their sensory evaluation and quality control.

Theory

UNIT I

Basic principles of food product development. Sensory properties of food and their role in product development. Formulation and evaluation of recipes at laboratory level. Bulk food preparation for food institutions and enterprises: servings, nutritive value and costing.

UNIT II

Evaluation of food- Objective and subjective methods, selection and training of judges, development of score cards and analysis of data.

UNIT III

Consumer evaluation-development of schedule and data analysis. Packaging material, types for different products. Food labeling.

UNIT IV

Food safety issues in product development, food quality regulations and standards, quality control and HACCP. Product formulation and development for general and therapeutic use.

Practical

Sensory evaluation, methods, training of judges, score card preparation.

Selection and modification of food product to be developed. Formulation and standardization of products. Objective and subjective evaluation of the products. Evaluation of consumer acceptability. Packaging and sale of products. Preparation of video film for media.

Suggested Readings

Altschul Aaron M. 1993. *Low Calorie Foods.* Marcel Dekker
Goldberg I. 1994. *Functional Foods: Designer Foods, Pharma Foods, Neutraceuticals.* Springer.
Matz SA. 2004. *Formulating & Processing Dietetic Foods.* CHIPS Publ.

14. FN 514 NUTRITION AND IMMUNITY 2+0

Objective

To make the students understand the importance of various nutrients in maintaining and improving the immunity of individuals.

Theory

UNIT I

Immunity: definition and history. Classification, immunological responses, cell types involved. Mechanism of phagocytosis and antigen-antibody reactions. Regulation of immunity. Mucosal defence system- effect of nutrients.

UNIT II

Effect of malnutrition on immunity. Carbohydrates and immune system. Fat and immune system- factors affecting acquired immunity. Protein and immune functions-effect of arginine, glutamine and sulphur amino acids. Glutathione and immune system.

UNIT III

Role of vitamins in immune functions-effect of deficiency. Role of minerals-effect of deficiency and excess on immune cell functions.

UNIT IV

Probiotics and antioxidants – their effect on immune function. Immunity against infection – role of immunization.

Suggested Readings

David A, Darlington G & Bendich A. 2004. *Diet and Human ImmuneFunction.* Humana Press.

Huffer T, Kanapa T & Stevenson GW. 1986. *Introduction to Human Immunology*. Jones & Bartlett.

Wise DJ & Carter GR. 2004. *Immunolgy - A Comprehensive Review*. Iowa State University Press, Blackwell Science Co.

15.FN 515 Food and Nutrition 2+0

Objective

To enable the students to know the basics of different types of food groups, composition, nutritive value, requirement and digestion and absorption of foods. This will also make them understand various nutritional problems of the community, assessment of nutritional status and about nutritional intervention programmes for vulnerable groups

UNIT I

Definitions- Health, nutrition, nutrients and nutritional status. Food its functions and classifications- food groups. Composition and nutritive value of common foods.

UNIT II

Nutrients- functions , sources, digestion and absorption and deficiency diseases. RDA for various of nutrients for various age, sex , and classes of individuals. Balanced diets and formulation

UNIT III

Common nutritional problems of India – causes. Assessment of nutritional status. Food borne infections and food hygiene. Toxicants in foods- Food adulteration

UNIT IV

Trends in food production and consumption in India. Effect of agricultural practices on the quality of foods . Post harvest losses- need for conservation. Food fortification, enrichment and restoration. Nutrition intervention programmes for vulnerable groups. Ensuring food security among population.

Suggested Readings

B. Srilakshmi. Nutrition Science , New age international (p)Ltd. Publishers

M. Swaminathan. Essentials of food and nutrition,Vol.I and II. Ganesh Company, Madras

Sumathy. R., Mudambi and Rajagopal , M.V, Fundamentals of foods and nutrition New age international (p)Ltd. New Delhi

Ph.D. COURSES

1.FN 601 ADVANCES IN CARBOHYDRATES, PROTEINS AND LIPIDS 3+1

Objective

To acquaint the students with recent developments in the role of carbohydrates, proteins and lipids in normal and diseased conditions.

Theory

UNIT I

Carbohydrates, proteins and lipids- Inborn errors of metabolism.

UNIT II

Metabolic disorders-diabetes, dental caries, obesity, atherosclerosis, hyperlipidemias and hypertension.Glucose homeostasis determined by insulin/glycogen ratio; carbohydrates free diet and its metabolic consequences; glycemic index; dietary fiber- its definition, composition, classification, functions and role in various physiological disorders.

UNIT III

Classification of protein, new discoveries in protein and their functions such as protein in Immune system, as lubricants, biological buffers and carriers, evaluation of protein quality: in vitro and in vivo methods, animal and human bioassays: amino acid pool, protein turnover in man with special reference to body size, age and various nutrition and pathological conditions, regulation of protein requirements; novel food sources of protein. Effect of insulin, corticosteroids, thyroids, androgen and growth hormone on protein metabolism, effect of dietary protein on cardiovascular disease and cholesterol metabolism, adaptation of body to low intake of energy and protein.

UNIT IV

Estimation of body fat; lipoproteins and hyper lipoproteinemia; hypolipidemic action of PUFA omega-3 fatty acids and oxidation products of cholesterol; lipids and cancer; fish oils in health and disease; oxidation products of cholesterol.Disturbance in lipid metabolism- high blood cholesterol –causes, prevention and treatment; hypolipidemic action of rice bran, oat, barley and legumes.

Practical

Assessment of protien quality; project work related to metabolic disorders of proximate principles; blood analysis in relation to NCD and estimation of amylase and protease inhibitors in foods.

Suggested Readings

Akoh CC & Min DB. 1998. *Food Lipids - Chemistry, Nutrition andBiotechnology.* Marcel Dekker.

Berdenier CD. 1976. *Carbohydrate Metabolism - Regulation and Physiological Role.* John Wiley.

Bodwell CE. 1979. *Evaluation of Protein for Human.* AVI Publ.

Dickens F. *Carbohydrate Metabolism and its Disorder.* Vol. II. Academic Press.

FAO. 1998. *Carbohydrates in Human Nutrition.* FAO.

FAO/WHO.1985. *Energy and Protein Requirements.* Technical Report Series 724.

Friedmen M.1975. *Protein Nutritional Quality of Foods and Feeds.* Part II. Marcel Dekker.

Lehninger Al. 1971. *Bioenergetics.* W.A. Benjamin.

Munro HN & Attoson JB. (Eds.). *Mammaliam Protein Metabolism.* Vols. I-IV. Academic Press.

Waterlow JC, Garlick PJ & Millerand DJ. 1978. *Protein Turnover in Mammalian Tissues and in the Whole Body.* North Holland Publ. Co.

2.FN 602 ADVANCES IN VITAMINS AND HORMONES 2+0

Objective

To acquaint the students with role and function, metabolism and recent developments in vitamins and hormones.

Theory

UNIT I

General definition and history of vitamins and hormones; cause of vitamin deficiencies in India. Chronology, chemistry, distribution, functions, absorption, transport, metabolism, deficiency manifestations,

UNIT II

Nutritional requirements, methods of assay. Interaction with other nutrients, antagonists and analogues of vitamins,

UNIT III

Hypervitaminosis of water and fat soluble vitamins; vitamin fortification and supplementation; endocrine and exocrine secretion of hormonesorgans of secretion, metabolism, mechanism of action, regulation and sites of action, biological effects and interaction.

UNIT IV

Assessments of vitamin status of population; antioxidants and their relationship with aging, cancer and other metabolic disorders.

Suggested Readings

Basu TK & Dickerson JWT. 1996. *Vitamins in Human Health and Disease.* CABI.

Combs GF. 1992. *The Vitamins, Fundamental Aspects in Nutrition and Health.* Academic Press.

Kutsky RJ. 1981. *Handbook of Vitamins and Minerals and Hormones.* NRC.

Machlin LJ. 1991. *Handbook of Vitamins.* Marcel Dekker.

3. FN 603 MINERALS IN HUMAN NUTRITION 2+1

Objective

To acquaint the students with role and functions, metabolism and recent developments in minerals

Theory

UNIT I

General definition and history of minerals; causes of macro and micro mineral deficiencies in India. Chronology, chemistry, distribution, functions, absorption, transport, metabolism, deficiency manifestations.

UNIT II

Nutritional requirements, methods of assay of all the minerals. Interactions of minerals with other nutrients, antagonists and analogues of minerals.

UNIT III

Assessment of mineral status of population, mineral fortification and supplementation; major mineral pollutants- their harmful effect to health; mutagenicity, carcinogenicity, teratogencity, heavy metal toxicity. Use of mineral isotopes/ tracers in nutritional studies.

UNIT IV

Metalonzymes; antioxidants and their relationship with aging, cancer and other metabolic disorders.; Trace minerals their chronology, chemistry, distribution, functions, absorption, metabolism, requirements, deficiency manifestation and interaction.

Practical

Assessment of antioxidants in foods; Project to combat micro nutrient deficiencies-Vulnerable sections, Groups with special needs.

Suggested Readings

Basu TK & Dickerson JWT. 1996. *Vitamins in Human Health and Disease* CABI.

Boyd LO' Dell & Sunde RA. 1997. *Handbook of Nutritionally Essential Mineral Elements.* CRC Press.

Causing 2005. *Annual Review of Nutrition.* Vol. 25.

Comb GF. 1992. *The Vitamins, Fundamental Aspects in Nutritional and Health.* Academic Press.

Kutsky RJ. 1981. *Handbook of Vitamins of Minerals and Hormones* NRC.

Machlin LJ.1991 *Handbook of Vitamins.* Marcel Dekker.

Monier Willam GW. 2008. *Trace Elements in Foods.* Agribios.

Taylor SL. 2007 *Advances in Food and Nutrition Research.* Vols. 1-52. Research Books & Pvt. Ltd.

4. FN 604 ADVANCES IN FOOD SCIENCE AND TECHNOLOGY 2+1

Objective

To acquaint the students with latest advances in nutrition and food science and food challenges in next millennium.

Theory

UNIT I

Recent advances in the field of carbohydrates, lipids, proteins, vitamins and minerals in relation to human nutrition.

UNIT II

Nutrogenomics, incorporating genetics into dietary guidance. Recent advances in the field of food analysis and food fortification.

UNIT III

Foods of future; special nutrients. Food processing and product development; regulating food processing and preservation through TQM and HACCP

UNIT IV

GM foods and their health implications; functional foods and organic foods, impact of WTO in food regulation.

Practical

Product development and shelf life of nutritionally fortified foods using advanced technologies, field study of food processing and preservation in relation to TQM and HACCP in an industry.

Suggested Readings

Manay NS & Shadaksharaswamy 1997. *Food Facts and Principles.* New Age Publ.

Potter N & Hotchkiss JH. 1996. *Food Scienc* . 5th Ed. AVI Book Van.

Potty VH & Mulky MJ. 1993. *Food Processing.* Oxford & IBH.

Srilakshmi B. 2002. *Nutrition Science.* New Age Publ..

Swaminathan MS. 1993. *Food Science and Experimental Foods.* Ganesh & Co.

5. FN 605 ADVANCES IN ENERGY METABOLISM 2+0

Objective

To familiarize the students with new developments in the area of energy metabolism and its relation to human health.

Theory

UNIT I

Scope and application of bioenergetics for human nutrition; energy types, energy store in man, its components and measurements.

UNIT II

Methods of estimation of energy requirement; factors affecting energy requirements and expenditure.

UNIT III

Thermogenesis; interrelationship between metabolic regulation. Mechanism of hunger and its energy cost of macromolecules.

UNIT IV

Weight control and obesity-role of adipose tissues. Effect of hormones on energy metabolism.

Suggested Readings

Lehninger AL & Benjamin WA. 1971 *Bioenergetic*. Meulo Park.

Causing 2005. *Annual Review of Nutrition.* Vol. 25.

Taylor SL.2007. *Advances in Food and Nutrition Research.* Vol- 1-52. Researcho Books.

FN 606 NUTRITION AND AGRICULTURAL INTERFACE 3+0

Objective

To acquaint the students with food production and consumption trends, food balance sheet and interrelationship between nutrition and agriculture development.

Theory

UNIT I

Food situation in India and in the world, food production and consumption trends; food balance sheets. Role of nutrition in agricultural planning and national development.

UNIT II

Linkages between agricultural practices; food production, food distribution and nutritional status; food crop failure and malnutrition; poverty and vicious cycle of low food production ; consumption indicators, nutritional status indicators and their role in agricultural planning.

UNIT III

Agricultural development and its effect on food availability; effect of food production and economic policies on food availability; impact of physical resources, farming systems, cropping system, inputs and manipulation, agricultural marketing system, post harvest processing of foods on food and nutrition situation; food distribution systems .

UNIT IV

Food and nutrition security at national and household level; nutrition policy implementation; nutritional impact of agricultural programmes, food price control and consumer subsidy; contribution of national and international organization for agricultural development.

Suggested Readings

Bhatia MS. 1991. *Agricultural Statistics at a Glance.* Ministry of Agriculture, Govt. of India, New Delhi. Census 1981, 1991, 2001.

India 2001. A Reference Annual. Publication Division, Ministry of Information about Broad casting, Govt. of India.

UNICEF 1999. *The State of World's Children.* Oxford University Press.

7. FN 607 NUTRITION IN EMERGENCIES 2+0

Objective

To acquaint the students with latest advances in management of food and nutrition in emergent situations.

Theory

UNIT I

Starvation in emergencies arising out of drought, floods, earth quakes, locust, war, wrong policies and poverty; historical perspectives.

UNIT II

Effect of inanition, short, medium and long term emergencies on food and nutrients intake, precautions against food shortage. Food needs at national level during normal emergencies,

UNIT III

Major nutritional deficiency diseases in emergencies; mobilization of local resources; general fund distribution; mass and supplementary feeding; therapeutic feeding; social funds.

UNIT IV

Control of communicable diseases; public health and hygiene problems during emergencies.

Suggested Readings

Messer E, Mark J, Cohen C & Jashinta D. 1998. *Food from Peace: Breaking the Links between Conflicts and Hunger.* IFPRI, Washington.

Spark A. 2007. *Nutrition in Public Health: Principles, Policies and Practice.* CRC Press.

The Management of Nutrition in Major Emergencies. 2000, WHO.

8. FN 608 APPLICATION OF BIOTECHNOLOGY IN FOODS AND NUTRITION 1+1

Objective

To acquaint the students with recent advances in role and application of biotechnology in Foods and Nutrition.

Theory

UNIT I

History, processes and products of biotechnology; application of biotechnology in production of nutritious foods.

UNIT II

Role of biotechnology in enzymology and product development, fermentation process, fruit juice extraction, genetic improvement of food grade microorganisms.

UNIT III

Nutritional significance of food products developed by biotechnological techniques.

UNIT IV

Scientific, technological and resource constraints on biotechnology; important factors affecting development in biotechnology.

Practical

Product development by biotechnological techniques

Suggested Readings

Nestle M. 2003. *Safe Food: Bacteria, Biotechnology and Bioterrorism.*University of California Press.

Rogers PL & Fleet GH. 1989. *Biotechnology and Food Industry*. University of Minnesota.

FN 609 GLOBAL NUTRITIONAL PROBLEMS 2+0

Objective

To enable the students to know the global nutritional problems and intervention programmes.

Theory

UNIT I

Food consumption pattern of developed and developing countries.

UNIT II

An overview of world nutrition situation and assessment of problems of developing countries in light of prevalence, etiology, Indicators and preventive measures.

UNIT III

An overview of world nutrition situation and assessment problems of developed countries in light of Prevalence, etiology, indicators and preventive measures.

UNIT IV

Nutrition and health programmes to alleviate malnutrition; role of national and international organizations.

Suggested Readings

Anderson L, Dibble MV, Turkki PR, Mitchell HE & Pynbergen HJ. 1982. *Nutrition in Health and Disease.* JB Lippincottt Co.

Jelliffee BD. 1966. *The Assessment of the Nutritional Status of the Community.* WHO.

Jolliffee N. 1962. *Clinical Nutrition.* Hoeber Medical Division.

Mclaren DS. 1983. *Nutrition in the Community.* John Wiley & Sons.

Park JE & Park K. 2000. *Text Book of Preventive and Social Medicine.*Barnasidas Bhanot Publ.

SCN News, United Nations. *System Forum on Nutrition.* WHO.

Shukla PK. 1982. *Nutritional Problems of India.* Prentice Hall of India.

FN 610 MATERNAL AND CHILD NUTRITION 2+1

Objective

To enable the students to understand the role of nutrition during pregnancy, lactation and infancy.

Theory

UNIT I

Current scenario of maternal and child nutrition; Nutritional aspect of embryogenesis; Factors affecting outcome of pregnancy; Physiological changes in body composition and mental development in relation to prenatal and postnatal nutrition .

UNIT II

Effect of nutritional status of mother on quantity and quality of breast milk; recent guidelines in infant feeding and complementary feeding. Feeding of premature babies; HIV and breast feeding; drug abuse and breast feeding.

UNIT III

Nutritional problems and requirements of preschool and school going children; growth and development of children; growth monitoring using growth charts.

UNIT IV

Strategies to improve maternal and child health in India ; role of BPNI in promotion of breast feeding in India; importance of world breast feeding week.

Practical

Preparation of a database on prevailing supplementary and weaning practices- planning, collecting data, analyzing data, writing report; preparation of low cost complementary foods. Analysis of weaning/complementary foods for its nutrient content.

Suggested Readings

Bamji MS, Rao NP & Reddy V.1999. *Text Book of Human Nutrition*. Oxford & IBH.

Falkner F & Tanner JM. 1978. *Human Growth - Postnatal Growth andNeurobiology*. Vol. II. Plenum Press.

Falkner F & Tanner JM. 1986. *Human Growth - A Comprehensive Treatise.* Development Biology Press.

Falkner F & Tanner JM. 1986. *Human Growth – Methodology, Ecological, Genetic and Nutritional Effects on Growth.* Vol. III. Plenum Press.

Francis DEM. 1986. *Nutrition in the Life Span.* John Wiley & Sons.NNMB Reports

Sachdeva HPS & Choudhary P. 1994. *Nutrition in Children*. Cambridge Press.

Williams SR, Worthington RS, Sneholinka ED, Pipes P, Ress JM & Mahal KL. 1988. *Nurition Throughout the Life Cycle*. Times Mirror/Mosby College Publ.

Ziegler EE & Filer LJ. 1996. *Present Knowledge in Nutrition.* International Life Science Institute, Washington, D.C.

List of Journals

- **Plant Foods for Human Nutrition**
  - Kluwer Academic Publisher, P.O. Box 322, 3300, AH Dordrecht, The Netherland
- **Journal of Food Science and Technology**
  - Association of Food Scientists, CFTRI, Mysore 570013 (India) afsti@soncharnet.in
- **Nutrition and Food Science**
  - www.emeraldinsight.com/authors
- **Food Chemistry**
  - Professor Gordon Birch, School of Food Biosciences, University of Reading, Whiteknights, Po Box 226, Reading RG6 6AP, UK
- **Journal of Human Nutrition and Dietetics**
  - Dr. Joan Gandy, Centre for Health Studies, Buckinghamshire Chilterns University College Gorelands Lane, Bucks, HP84AD, UK
- **International Journal of Food Science and Technology**
  - wttp:/mc.manuscriptcentral.com.ijfst
- **Journal of Indian Dietetic Association**
  - Editor-in-chief, Department of Biochemistry & Nutrition, All India Institute of Hygiene and Public Health, 110 C.R. Avenue, Kolkata – 700 073
- **International Journal of Food Science and Technology**
  - Blackwell Publishing Ltd. 9600 Garsington Road, Oxford, Ox42D.
- **Indian Food Packer**
  - K.P. Sareen, Executive Editor, All India Food Processors Association, 206, Aurobindo Place, Havzkhas, New Delhi
- **Trends in Food Science and Technology**
  - Elsevier Ltd., The Boulevard, Langfodlane, Kidlington, Oxford OXs 1GB, UK
- **European Journal of Clinical Nutrition**
  - JC Seidell, Free University, Amsterdam, The Netherlands.
- **Association of Food Scientists and Technologists** (India) Mysore
  - E-mail: aftsi@sancharnet.in.www.aftsi.org.
- **Journal of the Science of Food and Agriculture**
  - www.interscience.welley.com/jsfa

e-Resources

• www.eatright.org/
• www.fda.gov/search.html
• www.nutrition.about.com
• www.lifelines.com/ntnlnk.html
• www.fda.gov
• www.nal/usda.gov/fnic/dga
• www.nal.usda.gov/fnic/fpyr/pyramid.html
• www.diabetes.org
• www.5aday.com
• www.ificinfo.health.org/infoFN.htm
• www.fascb.org/asns/intro.html
• www.osteo.org
• www.ironoverload.org
• www.bookman.com.au.vitamins
• www.thriveonline.com/eats/vitamins/guide.index.html
• www.altmedicine.com/
• www.ncahf.org
• www.nal.usda.gov/fnic/foodcomp
• www.niddk.nih.gov/health/nutrit/nutrit.htm
• www.fda.gov/cder
• www.acsm.org
• www.cdc.gov/nccdphp
• www.nih.gov/od/oar
• www.americanheart.org
• www.nhlbi.nih.gov/index/htm
• www.cancer.org
• www.aice.org
• www.eatright.org/nfs42.html
• www.foodsafety.org
• www.safefood.org
• www.fao.org
• www.who.org/nut
• www.wfp.org
• www.worldbank.org

Suggested Broad Topics for Master's and Doctoral Research

• Diet and nutrition surveys of vulnerable sections of specific district
• Nutritional improvement and utilization of pearl millet and soybean in Indian dietaries
• Weaning/supplementary mixture for infants and pre school children
• Value added products from cereals and pulses
• Development and nutritional evaluation of β-carotene and iron rich products from amaranth, fenugreek, spinach and unconventional vegetables
• Development of foods for diabetes and old persons
• Development of fiber rich food products
• Development and nutritional evaluation of probiotic foods for controlling diarrhea
• Development and nutritional evaluation of value added products supplemented with crude palm oil and the vegetable oils
• Development and nutritional evaluation of value added products using medicinal plants and to test their efficacy against blood sugar and cholesterol level in animals and human beings
• Nutritional evaluation of under-utilized foods of India and incorporation in traditional diets to improve their nutritional quality
• Dietary survey of patients suffering from various diseases like, heart disease, liver disease, kidney disorder etc.
• Nutritional evaluation of new crop varieties and preparation of value added products

XVIII COMPULSORY NON-CREDIT COURSES

COURSE -AT GLAANCE

CODE	COURSE TITLE	CREDITS	Lead Dept.	Supporting depts.
PGS 501	RESEARCH METHODOLOGY	(1+1)	Extn	Path/Agro/Library
PGS 502 (e-Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0	Pbgn.	Biotech/Econ./Path./Ento. /Micr /Forestry
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1	Soil.Science	Pbgn./Biotech./Phys /Ento./Micr Path
PGS 505 (e-Course)	AGRICULTURAL RESEARCH , RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0	Extn	Path./Agro./ Econ Micr/Biot./Forestry./Hmsc
PGS 506 (e-Course)	DISASTER MANAGEMENT	1+0	Soil.Science	Agro./Extn./Ento/Path /Agmt./ Engg./Anhs

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1.PGS501 RESEARCH METHODOLOGY (1+1)

Objective

To equip the PG students to conceive research ideas and undertake research - both in field and in lab- on their own in pursuance of concrete ideas of research they formed for the development of agricultural research. The practical sessions will not only expose the students to certain live experiments currently being undertaken in the college but also enable the students to search, identify and utilize the relevant hard and soft literature resources and also to find ways and means to actually execute the survey/ experiments. At the end of the course the students will be able to analyse the data and interpret the results and to report and present the results using the state-of-the-art techniques.

Theory

UNIT I

Introduction: Origin and development of Agricultural research. Definition of research, research methodology; Motives and benefits of doing research.Philosophy of research; Methods of research - Induction and Deduction; Art of scientific investigation. Chance discoveries.

UNIT II

Types of research - Basic and Applied; Collection of qualitative and quantitative data. Methods of sampling - experiments and surveys. Experimental designs; Ensuring the quality of data - Precautions and vigilance Survey designs; Case studies; Action research; Participatory research.

UNIT III

Survey tools - Interview schedules, questionnaires etc. Items analysis; Pilot study. Fixing the sample size. Role of information in research planning and management; Information sources

UNIT IV

1. - Introduction to library and its services, information management.
2. Library classification systems - Colon classification, Dewey Decimal classification etc.; Selective Dissemination Services (SDS), Current Awareness Services (CAS).
3. Sources of information - primary, secondary and tertiary. Information retrieval systems - Online and Offline information sources and databases, CD-ROM databases.
4. Indexing and abstracting; Library networks; Modern information systems - AGRIS, CABI, CARIS, AGRICOLA etc.
5. Fixing the objective of research, research hypothesis and time and venue of research.
6. Finding the funding agencies for agricultural research experiments/ field surveys. Research management - Manning the research and building the research infrastructure.
7. Collection and analysis of data. Statistical analysis - Tests of hypothesis, Drawing inference. Data entry and verification.
8. Use of Statistical packages - Packages for Statistical investigation and Social Sciences. Preparing diagrams and charts. Validation and correction of data and results; Importance of safe storage of data and results.
9. Documenting and reporting research results - Preparation of research papers - Structuring, Content validation, Acknowledgement etc.

10. Reference citation - styles - Style adopted for Journal of Tropical Agriculture (KAU). Tips for technical writing. Proof reading.
11. Public presentation of research results - Tools and tips for effective communication.
12. Preparation of slides - Conventional methods, Computer Aided presentations - Power of Power point.

Practical Schedule

1. Use of Library - Familiarization with various features of library.
2. Locating books and other documents using library catalogue- Colon and DDC
3. Computer-aided literature search - Familiarization of important databases such as CABS, CARIS, AGRIS, AGRICOLA, Biological abstracts etc.
4. Paraphrasing
5. Note taking and preparation of index cards
6. Structure of a research paper
7. Structure of a thesis
8. Exercises on citing and listing references
9. Exercises on processing of data and illustrations
10. Formulation of a research project
11. Presentation of scientific papers
12. Common errors in technical writing
13. Errors in using 'units' - SI system and familiarization with units
14. Proof correction practice
15. Preparation of a poster for display and use of "Power point" package
16. Familiarization with internet and search engines.

Suggested Reading

Kerlinger
AK Singh
Joseph, G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.

Evaluation - 100 marks

2. PGS 503 Intellectual property rights and plant breeding 1+0

Theory

Property rights – (IPR) issues involved – Nature of IPR. Patents – Conditions for patents – Historical aspects of patents - Patents in India – case studies. Indian Patent Act – Facilitating patents – Intellectual Property Management Division (IPMD) under CSIR. Copy rights – History of copy right protection – Fair Dealing - copy right protection in India. Trade marks – purpose, importance, systems, trade mark protection.Geographical indications (GI) – benefits – protection of GI – national & international level – goods that can be protected under GI – procedure, violation of GI protection – examples. IPR on plant varieties –PPV & FR Act, 2001 .IPR on biological diversity – Convention on Biological Diversity (CBD. ICAR guidelines for IPR management. Biodiversity Act.Seed Bill – its impact. Various treaties – their comparisons. IPR and participatory technology .Implications of IPR in commercializing products- biotechnological innovations etc.,

Suggested readings

Chahal, G. S and Gosal, S. S. 2002. *Principles and Procedures of Plant Breeding.* Narosa Publishing House, New Delhi
Maskus, K.E. (2000), *Intellectual Property Rights in the Global Economy*, Washington,D.C.: Institute for International Economics.

Elsy, C.R., Jesy Thomas, K. and Mohandas, M. 2006. Primer on IPR in Agriculture. Kerala Agricultural University, Thrissur. p.36
www.wipo.org
related websites

3.PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings

Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

4.PGS 505 (e-Course) AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES 1+0

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT 1

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Reseach Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT 2

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT 3

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes : Community Development Programme, Intensive Agricultural District Programme, Special group- Area Specific Programme,

Integrated Rural Development Programme(IRDP),District Rural Development Agency (DRDA),Rashtriya Krishi Vikas Yojana (RKVY),Swarna Jayanti Swaraskar Yojana (SGSY), Kudumbasree, Self Help Groups (SHGs), Agriculture Management Technology Agency (ATMA),Gender and Development,Women Empowerment,Youth Development Programmes, Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS & Singh G.2001. Indian Agriculture- Four Decades of Development.Sage Publ.

Grover I. 2008.Handbook on Empowerment and Entrepreneurship. Agrotech Publishing Academy, Udaipur.

Punia MS> Manual on International Research and Research Ethics .CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions- Isssues, Innovations and Initiatives.Mittal Publ.

Rout HS and Panda PK (eds) 2008 .Gender and Development in India-dimensions and Strategies.New Century Publ, New Delhi.

Singh K.. 1998.Rural Development-Principles,Policies and Mangement.Sage Publ.

Rout HS and Panda PK (eds) 2008 .Gender and Development in India-dimensions and Strategies.New Century Publ, New Delhi.

5.PGS 506 DISASTER MANAGEMENT 1+0 (e-Course)

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I

Natural Disasters - Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves, Climatic change: Global warming, Sea level rise, Ozone depletion

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media.

Central, state, district and local administration; Armed forces in disaster response; Disaster response: Police and other organizations.

Suggested Readings

Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.

Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.