

PG SYLLABUS

for

M.Sc.(Agriculture) & Ph.D.(Agriculture)



उत्तमा वृत्तिस्तु कृषिकर्मैव

**Swami Keshwanand Rajasthan Agricultural University,
Bikaner**

Foreword

The Indian Council of Agricultural Research (ICAR) over the years has developed strong academic linkages with various institutions and professionals of the country to induce vital reforms in agricultural education for improving its quality, relevance and uniformity across the country. For restructuring of PG academic programme, a National Core Group(NCG) constituted by the ICAR has now mandated to revise the curricula and syllabi of Masters and Doctoral programmes in all the disciplines of agriculture. The NCG further constituted 18 Broad Subject Matter Area (BSMA) Committees to undertake this exercise in their respective subject matter domains.

The present syllabus is an adoption of “new and restructured post-graduate curricula & syllabi in Agriculture as recommended by ICAR, New Delhi has been implemented in Swami Keshwanand Rajasthan Agricultural University, Bikaner from the academic session 2009-10.

A list of relevant and latest reference books has been provided for each course. Commonly used journals and websites pertaining to the all subjects have been included for the benefit of the students and faculties. I thank to all Head of the Departments and the members of the committee of courses as well as dedicated teachers of various departments of Swami Keshwanand Rajasthan Agricultural University, Bikaner for their incessant enthusiasm and critical comments and inputs which resulted in this compilation. I sincerely acknowledge their valuable cooperation and contributions. While every effort has been made to make this document error free, yet suggestions if any are welcome for incorporation.

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AGRONOMY

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	AGRON 511	AGROMETEOROLOGY AND CROP WEATHER FORECASTING	3(2+1)
2.	AGRON 512*	PRINCIPLES AND PRACTICES OF WATER MANAGEMENT	3(2+1)
3	AGRON 513*	PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT	3(2+1)
II- Semester			
4.	AGRON 521*	MODERN CONCEPTS IN CROP PRODUCTION	3(3+0)
5.	AGRON 522*	PRINCIPLES AND PRACTICES OF WEED MANAGEMENT	3(2+1)
6.	AGRON 523	DRYLAND FARMING AND WATERSHED MANAGEMENT	3(3+0)
7.	AGRON 524	CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE	3(3+0)
8.	AGRON 525	AGROSTOLOGY AND AGROFORESTRY	3(2+1)
III- Semester			
9.	AGRON 531	AGRONOMY OF MAJOR CEREALS AND PULSES	3(2+1)
10.	AGRON 532	AGRONOMY OF OILSEEDS, FIBRE AND COMMERCIAL CROPS	3(2+1)
11.	AGRON 533	AGRONOMY OF KHARIF PULSES AND FORAGE CROPS	3(2+1)
12.	AGRON 534	PRINCIPLES AND PRACTICES OF ORGANIC FARMING	3(2+1)
13.	AGRON 535	AGRONOMY OF MEDICINAL, AROMATIC AND UNDER UTILIZED CROPS	3(2+1)
IV- Semester			
14.	AGRON 541	SEMINAR	1
15.	AGRON 542	COMPREHENSIVE	2
16.	AGRON 543	RESEARCH	15
Ph.D.			
I- Semester			
1.	AGRON 611*	ADVANCES OF CROP GROWTH AND PRODUCTIVITY	3(2+1)
2	AGRON 612*	ADVANCES IN WEED MANAGEMENT	3(3+0)
3.	AGRON 613	CROP ECOLOGY	3(3+0)
II- Semester			
4.	AGRON 621	IRRIGATION MANAGEMENT	3(2+1)
5.	AGRON 622	STRESS CROP PRODUCTION	3(2+1)
6.	AGRON 623	SOIL CONSERVATION AND WATERSHED MANAGEMENT	3(2+1)
8.	AGRON 624	CURRENT TRENDS IN AGRONOMY	3(3+0)
9.	AGRON 625	INTEGRATED FARMING SYSTEMS	3(3+0)
10.	AGRON 626	CROP PRODUCTION AND SYSTEM MODELING	3(2+1)
III- and onward semesters			
11.	AGRON 641	SEMINAR	2
12.	AGRON 642	PRELIMINARY	4
13.	AGRON 643	RESEARCH	40

* Core courses

AGRONOMY

M.Sc. Programme

AGRON 511
3(2+1)

Agro-meteorology and Crop Weather Forecasting

Objective

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

Theory

Agro meteorology: aim, scope and development in relation to crop environment, composition of atmosphere, distribution of atmospheric pressure. Solar radiation: characteristics, energy balance of atmosphere system, radiation distribution in plant canopies, radiation utilization by field crops, photosynthesis and efficiency of radiation utilization by crops, energy budget of plant canopies. Environmental temperature: soil, air, canopy temperature, temperature profile in air, soil and crop canopies, soil and air temperature effects on plant processes, regulation of air, soil temperature for protection against frost and hot winds. Environmental moisture and evaporation, measures of atmospheric moisture, temperature, relative humidity, vapour pressure and their relationship, evapotranspiration and meteorological factors determining evapotranspiration. Modification of plant environment: artificial rain making, controlling heat load, heat trapping and shedding, protection from cold, reduction in sensible and latent heat flux.

Monsoon: monsoon and their origin, characteristics of monsoon, onset and progress of monsoon, withdrawal of monsoon. Weather forecasting in India: short, medium and long range forecasting, benefits of weather service to agriculture, forecasting of destructive frost, soil moisture forecast, phenological forecast, crop yield forecast. Aero-space science and remote sensing : application in agriculture, present status of remote sensing in India. Atmospheric pollution and its effect on climate and crop production.

Practical

Agro-meteorological observatory- classes, site selection, layout and installation of meteorological instruments; handling of meteorological instruments; measurement of weather parameters; working out agro-climatic indices; maintenances of record; calculation of daily, weekly and monthly means; visit to state remote sensing centre, Jodhpur/Jaipur; measurement of soil temperature in different soil conditions/depths; interpretation and use of weather data; rainfall analysis for variability; moisture availability indices for an arid and a humid district, length of growing season, fitting cropping systems; preparation of weather maps, synoptic charts and weather reports; preparation of crop weather calendars, to become familiar with agro advisory service bulletins visit to ARS, Durgapura/Bikaner.

Suggested Readings

- A.A. Rama Sastu (1984). Weather and Weather forecasting Publication Division, GOI.
A.K. Sacheti, 1985. Agricultural Meteorology- Instructional-cum-Practical Manual. NCERT, New Delhi.
Critchfield, H.J. 1995. General Climatology, Prentice Hall of India Pvt. Ltd., New Delhi

D.S. Lal, 1998. Climatology. Sharda Pustak Bhawan.

H.S. Mavi (1994). Introduction to Agro-meteorology. Oxford & IBH Publishing Co. New Delhi.

K.L. Joshi, Sinha and D.P. Gupta (1985). Physical Geography, National Council of Educational Research and Training, New Delhi.

Mavi H.S. and Tuper G.J. 2004. Agro-meteorology: Principles and Application of Climate Studies in Agriculture. Haworth Press.

P.A. Menon (1989). Our weather. National Book Trust, New Delhi.

P.K. Das (1992). The Monsoon. National Book Trust, New Delhi.

R.S. Gena and S.P. Seetharaman (1991). Natural Resource Management: The Role of Remote sensing in decision making. Oxford & IBH Publishing Co. New Delhi.

S. Venkateraman and A. Krishnan. Crops and Weather. Indian Council of Agricultural Research, New Delhi.

S.R. Ghadekar, 1991. Meteorology, Agromet Publishers, Nagpur.

Vashneya M.C. and Balakrishana Pillai P. 2003. Textbook of Agricultural Meteorology, ICAR.

Vasiraju Radha Krishna Murthy (1995). Practical Manual on Agricultural Meteorology, Kalyani Publishers, Ludhiana.

AGRON 512 Principles and Practices of Water Management

3(2+1)

Objective

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

Theory

Water, its properties and role in plants; Water resources of India, Major irrigation projects and extent of area and crops irrigated in India; Water potential – concept, components and relationship between different components; Water movement in plant and soils; Absorption and transpiration of water in plants; Scheduling and methods of irrigation including micro irrigation system; Fertigation, Water use efficiency: Water management of crops and cropping systems; Soil, plant and meteorological factors determining water needs of crops; Water deficit stress in plants and its effect on growth. Quality of irrigation water – effect of saline water and soil salinity on plants and its management, Excess soil water and plant growth; Water management in problem soils; Drainage requirement of crops and methods of drainage, their layout and spacing. **Practical**

Determination of soluble salts, $\text{Ca} + \text{Mg}$, $\text{CO}_3^{=}$ and HCO_3^- and Na in irrigation water; Determination of FC and PWP; Soil moisture measurement by tensiometer and pressure plate apparatus; Water flow measurement using different devices. Determining soil profile moisture deficit and irrigation requirement. Calculations on irrigation efficiencies; Computation of water requirement of crops using modified Penman formula. Determination of infiltration rates and hydraulic conductivity.

Suggested Readings

A.M. Michael, 1987. Irrigation – Theory and Practice, Vikas Publishing House Pvt. Ltd., New Delhi

S.S. Parihar and B.S. Sandhu, 1978. Irrigation of field crops – Principles and Practices, ICAR, New Delhi

D. Lenka, 1999. Irrigation and Drainage. Kalyani Publishers, New Delhi.

R.D. Mishra and M. Ahmed. 1987. Manual on Irrigation Agronomy, Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi

G.H. Sankara Reddy and T. Yellamanda Reddy. 1995. Efficient use of irrigation water. Kalyani Publishers, New Delhi

K.V. Paliwal. 1972 Irrigation with saline water WTC, IARI, New Delhi.

I.C. Gupta 1990. Use of saline water in Agriculture. Oxford & IBH Pub. Co. Ltd., New Delhi

P.J. Kramer and J.S. Boyer 1995. Water relations of Plants & Soils, Academic Press, California, USA.

S.R. Reddy 2000. Principles of Crop Production, Kalyani Publication, New Delhi.

D.K. Majumar 2004. Irrigation water management – principles and practice, Prentice Hall of India, New Delhi.

S.C.Panda 2003. Principles and practices of water management. Agrobios, Jodhpur

Singh Pratap and Maliwal P.L. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publc.

AGRON 513 Principles and Practices of Soil Fertility & Nutrient Management 3(2+1)

Objective

To impart knowledge of soil fertility and plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil resources.

Theory

Problems and management relating to mechanical impedance and soil submergence; Salt affected soils - problems and remedial measures; Soil acidity and remedial measures; Soil fertility and productivity concept and differences: Criteria of essentiality and forms in which nutrients are absorbed by plants; Physiological methods of increasing FUE.

Nitrogen: Functions, deficiency and toxicity symptoms, forms of nitrogen, nitrogen transformation in soil, organic and mineral N balance in soil, mineralization of N compounds, losses of N from soil, nitrogenous fertilizer materials. Methods to increase N use efficiency and slow release fertilizers; Biological N fixation, symbiotic and free living N fixers; **Phosphorus:** Functions and deficiency symptoms, forms of P in soil, their availability and P fixation, various phosphatic fertilizers; Practices of increasing the effectiveness of applied and native phosphorus (PSB). **Potassium:** Functions and deficiency symptoms, forms of K in soil, fixation and release of potassium in soil; Potassic fertilizers and their application. Sulphur and micronutrients (Fe, Zn) functions, deficiency symptoms and application; Inter relationship of nutrient availability and soil pH; Important nutrient interactions and their effect on nutrient availability, cation exchange capacity and availability of plant nutrients; Integrated nutrient management.

Practical:

Procedure of plant and soil sampling; Determination of soil pH, EC and organic carbon; Determination of total N and available N, P and K in soils; Determination of N, P, K and S in plant samples; Determination of Ca, Mg and Na in soil; Determination of gypsum requirement of alkali soils.

Suggested Readings

S.L. Tisdale, W.L. Nelson, J.D. Beaton and J.L. Havlin. 1997. Soil Fertility and Fertilizers. Prentice Hall of India, Pvt. Ltd., New Delhi

T.R. Reddy and G.H.S. Reddi 1992. Principles of Agronomy, Kalyani Publishers, New Delhi

L.A. Richards, 1968. Diagnosis and Improvement of Saline and Alkali Soils, Oxford and IBH Publishing Company, New Delhi

Tamhaney, Motiramani, Bali and Donahu, 1970. Soils Their Chemistry and Fertility in Tropical Asia, Prentice Hall of India, New Delhi

R.R. Agarwal, J.S. P. Yadav and S.N. Gupta, 1982. Saline and Alkalai soils of India. ICAR Publication, New Delhi

G.Singh, J.S. Kolar and H.S. Sekhon, 2002. Recent Advances in Agronomy, Indian Society of Agornomy, IARI, New Delhi

J.S. Kanwar, 1978. Soil Fertility: Theory and Practices, ICAR Publication, New Delhi

J.L. Havlin, J.D. Beaton, S.L. Tisdale and WL. Nelson, 2006. Soil Fertility and Fertilizers- An Introduction to Nutrient Management, Prentice Hall of India, Pvt. Ltd., New Delhi

N.C. Brady and R.R. Weil, 2003. Elements of the Nature and Properties of Soils. Prentice Hall, New Jersey.

R.S. Yawalkar, J.P. Agarwal and J. Bokde 1992. Manures and Fertilizers. Agri-Horticultural House, Nagpur

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

AGRON 521

Modern Concepts in Crop Production

3(3+0)

Objective

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

Theory

Agronomic aspects in food security; Crop growth and production in relation to climate change; Agro ecological and agroclimatic zones of India; Concept of potential yield; Modern concepts in tillage- zero, minimum and conservation tillage; Optimization of plant population and planting geometry in relation to soil fertility, solar radiation and available moisture regimes; Mitscherlich , Baule and Inverse yield : nitrogen laws; Biotic and abiotic stresses; Concept of ideal plant type; Organic farming, Physiology of grain yield in cereals; Crop growth analysis; Crop modelling in agronomic systems; Precision agriculture; Growth regulators and their role in agriculture; Designer crops; Vermi-technology; Agro biodiversity; Seed priming; ; Indigenous technological knowledge; Herbicide resistance in weeds; Allelopathy in agriculture ; Plant nutrition and disease tolerance in field crops.

Suggested Readings

Gardner, F.P.;Pearce, G.R. and Michell, R.I. Physiology of Crop Plants, Scientific Pub., Jodhpur.

S.P. Palaniappan and Shivarama,K. 1996. Cropping Systems in the Tropics - Principles and Management. New Age International Pub.

Fageria, N.K. 1992. Maximising crop yields. Marcel Dekker, New York.

Reddy,S.R. 2000. Principles of Agronomy. Kalyani Pub. New Delhi.

Sankaran, S. and Mudaliar ,T.V.S. 1997. Principles of Agronomy. The Bangalore Printing and Pub. Bangalore.

Redford, J. 1967. Growth Analysis formulae: Their use and abuse. Crop Science. 76:171-175.

Singh, G.; Kolar, J.S. and Sekhon, H.S. 2002 Recent Advances in Agronomy (Ed). ISA, Publication, New-Delhi.

Paroda, R.S. 2003. Sustaining Our Food Security. Konark Publishers Pvt. Ltd., Delhi

Balasubrammanian P. and Palaniappan, S.P. 2001. Principles and Practices of Agronomy. Agrobios

Havlin J.L., Beaton J.D., Tisdale S.L. and Nelson W.L. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.

Objective

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

Theory

Weed – biology, ecology and classification; history, development and classification of herbicides, their properties, mode of action and uses, basis of selectivity of herbicides; herbicide mixtures, adjuvants and safeners; weed control principles and management practices in important grain crops, oilseeds, pulses, sugar, fibre crops, tuber crops and forage crops; vegetables and orchards; weed control under specific situations viz. intercropping systems, non cropped areas and drylands; noxious farm weeds and parasitic weeds and their control; fate of herbicides in soil; herbicide - pesticides and fertilizer interactions; allelopathic effect; integrated weed management; problem of aquatic weeds particularly water hyacinth, hydrilla and typha grass in Rajasthan and their possible control measures; weed control through bio herbicides and myco- herbicides; herbicide resistance in weeds and crops.

Practical

Identification of common *kharif*, *rabi* and perennial weeds of crop fields, road sides, waste lands and irrigation channels; familiarization with trade names, common names, uses, cost and source of availability of herbicides; calibration of sprayer and maintenance (before and after use); study of different herbicidal formulations; calculation on herbicidal requirement for field crops and aquatic situation; application of herbicides in field crops; control of some noxious weeds by cultural and chemical means; study on weed control efficiency and calculation on weed infestation and weed index; preparation of weed herbarium, methodology for weed control research and precautions in handling or storage of herbicides.

Suggested Readings

- Aldrich RJ & Kramer RJ. 1997. *Principles in Weed Management*. Panima Publ.
Ashton FM & Crafts AS. 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 & Kumar RJ. 1997. *All About Weed Control*. Kalyani.
Zimdahl RL. 1999. *Fundamentals of Weed Science*. 2nd Ed. Academic. Press

Objective

To teach the basic concepts and practices of dryland farming, soil moisture conservation and watershed management.

Theory

Definition, concept, significance and dimensions of dryland farming in Indian agriculture, characteristics of dryland farming and dryland versus rainfed farming: constraints limiting

crop production in dry land areas; characterisation of environment for water availability; delineation of dry farming areas on the basis of moisture deficit index and their characteristics, use of mulches, kinds, effectiveness and economics; antitranspirants- their types, mechanism and role in dry farming; water harvesting- its concepts, techniques and practices; soil and crop management techniques- tillage, seeding, fertilizer use, crop and varietal choice, cropping system, weed control and other management practices; plant ideotypes for drylands, drought management strategies; preparation of appropriate crop plans for dryland areas; mid season corrections for aberrant weather conditions. Watershed management- definition, objectives, concepts, problems, approach components, development of cropping systems for watershed areas; alternate land use systems; planning and operation of project for watershed management.

Suggested Reading:

- Efficient Crop Management in Dry Farming Areas. 1985. ICAR (CRIDA) Publication, Hyderabad.
- J.C. Katyal and J. Farrington, 1995. Research for Rainfed Farming, CRIDA, Hyderabad.
- Mahendra Pal, K.A. Singh and I.P.S. Ahlawat. 1985. Cropping System Research I & II. In processing of the National Symposium on Cropping Systems Published by ISA, New Delhi.
- N.R. Das, 2007. Tillage and crop production. Scientific Publishers, Jodhpur
- P. Ramaswamy, 1982. Dry farming technology in India. Agricole Publishing Academy, New Delhi.
- R.D. Asana, 1968. Growth Habit & Crops of Non-Irrigated Areas, Important Characters of Plant Types, Ind. Farming, 81:25-27.
- R.P. Singh 1995. Sustainable Development of Dryland Agriculture in India, Scientific Publishers, Jodhpur.
- R.P. Singh, Srinivas Sharma, M.V. Padmanabhan, S.K. Das and P.K. Mishra, 1990. A Field Manual on Watershed Management, ICAR (CRIDA) Publication, Hyderabad.
- S. Palaniappan. 1985. Cropping Systems in Tropics: Principles and Management, Wiley Eastern Ltd., New Delhi & TNAU, Coimbatore.
- S.C. Rao and J. Ryan 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publishers., Jodhpur.
- S.C. Verma and M.P. Singh. 1984. Agronomy of New Plant Types. Tara Book Agency, Varanasi.
- S.D. Singh, Water harvesting in Desert, Manak Publication, New Delhi.
- T.Y. Reddy and C.H. Shankara Reddi. 1992. Principles of Agronomy, Kalyani Publishers, New Delhi.
- U.S. Gupta, 1975. Physiological Aspect of Dryland Farming, Oxford & IBH, New Delhi.
- U.S. Gupta. 1995. Production and Improvements of Crops for drylands, Oxford & IBH Publishing Co. Ltd, New Delhi
- V.V. Dhurva Narayan, R.P. Singh, S.P. Bhardwaj, M., Sharma, A.K. Sikka, K.P.R. Vittal and S.K. Das. 1987. Watershed Management for Drought Mitigation, ICAR Publication, New Delhi.

AGRON 524 Cropping Systems and Sustainable Agriculture

3(3+0)

Objective

To acquaint the students about prevailing cropping systems and sustainable agriculture in the country and practices to improve productivity.

Theory:

Cropping systems- intercropping and multiple cropping, concepts, needs, indices and assessment; existing cropping systems under irrigated and rainfed situations. Cropping system indices viz., relative spread index and relative yield index. Farming system: integrated farming system, alternate farming system - meaning and scope including specific examples. Recycling and crop residue management. Natural farming - concept and components. Organic farming. Crop diversification – principles, types and needs. Sustainable agriculture - definition, scope and objectives, Natural resources, their characterization and management; Sustainable cropping and farming systems in agriculture in relation to environmental degradation; Research needs on sustainable agriculture.

Suggested Readings

- Guriqbal Singh, J.S. Kolar and H.S. Sekhon 2002. Recent Advances in Agronomy, Indian Society of Agronomy, IARI, New Delhi
- K. Balakrishnan Nair, U.N. Goswami and K. Kunhkrishnan 1972 (Ed.) Proceedings of the Symposium on Cropping Patterns in India. ICAR Publication, New Delhi.
- K.N. Singh and R.P. Singh (Eds), 1990. Agronomic Research Towards Sustainable Agriculture, Indian Society of Agronomy, New Delhi
- L.L.Somani, K.L. Totawat and B.L. Baser. 1992 (Ed.) Proceedings of National Seminar on Natural Farming, NSMP Publication, Rajasthan College of Agriculture, Udaipur
- Proceedings of the National Symposium on Cropping Systems 1985. Indian Society of Agronomy, New Delhi
- R.M. Devlin and E.H. Watham. 1986. Plant Physiology. CBS Publishers and Distributors, New Delhi.
- R.P. Singh, 1990. Sustainable Agriculture: Issues ,Perspectives and Prospects in Semi Arid Tropics. Vol I & II Indian Society of Agronomy, New Delhi
- R.W. Willey 1979. Intercropping: Its Importance and Research Needs, Field Crop Abstracts 332:1-10 & 73-81
- S.C. Panda. 2004. Cropping Systems and Farming Systems. Agrobios (India) Jodhpur
- Singh, S.S. 2006. *Principles and Practices of Agronomy*. Kalyani Publishers, Ludhiana.

AGRON 525

Agrostology and Agro-Forestry

3(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; agroforestry systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.

UNIT IV

Crop production technology in agro-forestry 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 silvipastoral 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 BN & Das PK. 1989. *Forage Crop Production. Principles and Practices*. Oxford & IBH.
- Dabadghao PM & Shankaranarayan KA. 1973. *The Grass Cover in India*. ICAR.
- Dwivedi AP. 1992. *Agroforestry- Principles and Practices*. Oxford & IBH.
- Indian Society of Agronomy. 1989. *Agroforestry System in India. Research and Development*, New Delhi.
- Narayan TR & Dabadghao PM. 1972. *Forage Crop of India*. ICAR, New Delhi.
- Pathak PS & Roy MM. 1994. *Agroforestry System for Degraded Lands*. Oxford & IBH.
- Sen NL, Dadheech RC, Dashora LK & Rawat TS. 2004. *Manual of Agroforestry and Social Forestry*. Agrotech Publ.
- Shah SA. 1988. *Forestry for People*. ICAR.
- Singh, Punjab, Pathak PS & Roy MM. 1994. *Agroforestry System for Sustainable Use*. Oxford & IBH.
- Singh SP. 1994. *Handbook of Agroforestry*. Agrotech Publ.
- Solanki KR. 2000. *Multipurpose Tree Species: Research, Retrospect and Prospects*. Agrobios.
- Tejwani KG. 1994. *Agroforestry in India*. Oxford & IBH.

AGRON 531 Agronomy of Major Cereals and Pulses

3(2+1)

Objective

To teach the crop husbandry of major cereals and pulses.

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 of rice, wheat, maize, barley, sorghum, pearl millet, chickpea and pigeon pea.

Practical

Phenological studies at different growth stages of crops, different methods of raising nursery including dapog in rice; estimation of crop yields on the basis of yield attributes; calculation of fertilizer requirements and their application at different stages of growth on the basis of soil test values; computation of cost of cultivation of various crops, planning

and layout of field experiments, formulation of cropping scheme for various farm sizes, calculation of cropping and rotation intensities, visit of field experiments for cultural, fertilizer, weed control and water management aspects; working out indices of intercropping systems – L.E.R. aggressivity, relative crowding coefficient and monetary yield advantage, ATER; determination of physiological maturity in different crops; working out of harvest index in various crops; computation of growth analysis indices. Study of root nodules and seed treatment with bio-fertilizers in pulses, Estimation of protein in pulses.

Suggested Readings

- B.N. Chatterjee and K.K. Bhattacharya, 1986. Principles and Practices of Grain Legume Production, Oxford & IBH Publishing Company, New Delhi.
- D.S. Yadav, 1992. Pulse Crops, Kalyani Publishers, New Delhi.
- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Hunsigi G & Krishna KR. 1998. *Science of Field Crop Production*. Oxford & IBH.
- Jeswani and Baldev, 1990. Advances in Pulse Production Technology, ICAR Publication, New Delhi.
- Khare D & Bhale MS. 2000. *Seed Technology*. Scientific Publ.
- Kumar Ranjeet & Singh NP. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.
- P.S. Rathore 2000. Techniques and Management of Field Crop Production. Agrobios (India) Jodhpur.
- Pal M, Deka J & Rai RK. 1996. *Fundamentals of Cereal Crop Production*. Tata McGraw Hill.
- Prasad, Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.
- Singh C., Singh Prem and Singh Rajbir, 2003. Modern Techniques of Raising Field Crops. Oxford & IBH Publishing Co., New Delhi.
- Singh, SS. 1998. *Crop Management*. Kalyani Publishers.

AGRON 532 Agronomy of Oilseeds, Fibre and Commercial Crops 3(2+1)

Objective

To teach the crop husbandry of oilseed, fibre and commercial 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 oilseeds - groundnut, rapeseed and mustard and soybean; fibre crops - cotton and jute and commercial crops-sugarcane and potato.

Practical

Phenological studies at different growth stages of crops, study of yield attributing characters of oilseeds and cotton; computation of yield on the basis of yield attributing characters; determination of protein and oil content in oilseeds, Seed treatment of cotton seed with sulphuric acid and cow dung; computation of cost of cultivation of various crops; determination of quality of cotton including ginning per cent and lint index; calculation of fertilizer requirements and their application at different growth stages in various crops on the basis of soil test values. cutting of cane setts, its treatment and

method of sowing, tying and propping of sugarcane; determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in juice; preparation of blue print for sugarcane, calculation of seed rate and fertilizer requirement for sugarcane; to work out the cost of cultivation of sugarcane; selection of potato seed, its treatment and method of sowing; calculation of seed rate and fertilizer requirement for potato; preparation of blue print for potato;

Suggested Readings

- B. Sundara 1998. Sugarcane cultivation. Vikas Publishing House Pvt. Ltd.
 B.C. Biswas, S. Maheshwari, C. Singh and D.S. Yadav 1984. Cotton, Published by Fertilizer Association of India, New Delhi.
 Chhidda Singh, Prem Singh and Rajbir Singh, 2003. Modern Techniques of Raising Field Crops. Oxford & IBH Publishing Co., New Delhi.
 Das, N.R. 2007. Introduction to crops of India. Scientific Publisher, Jodhpur.
 H.C. Srivastava, S. Bhaskaran, B. Vatsyas and K.K.G. Menon, 1985. Oilseed Production: Constraints and Opportunities, Oxford & IBH Company, New Delhi.
 J.S. Grewal & V.P. Jaiswal. 1990. Agronomical studies in potato under all India Coordinated Potato Improvement Project, CPRI Pub. Shimla.
 J.S. Grewal, R.C. Sharma, S.S. Saini. 1991. Agro-techniques for Intensive Potato Cultivation in India, ICAR Publication, New Delhi.
 P.S. Bhatnagar and S.P. Tiwari, 1990. Technology for increasing soybean production in India, NRCS, Technical Bulletin (ICAR), National Research Centre for Soybean, Indore.
 P.S. Rathore 2000. Techniques and Management of Field Crop Production, Agrobios (India) Jodhpur
 P.S. Reddy, 1988. Groundnut, ICAR, New Delhi.
 Rajendra Prasad, 2002. Text book of field crops production ICAR Pub.
 Research and Development Strategies for Oilseed Production in India, 1979. Proceedings of National Symposium, 7-9 Nov. 1979, ICAR Publication, New Delhi.
 S.C. Verma and M.P. Singh, 1987. Agronomy of New Plant Types, Text Book Agency, Varanasi.
 S.S. Singh, 1988. Crop Management under Irrigated and Rainfed Conditions, Kalyani Publishers, New Delhi.
 S.S. Srivastava, D.P. Johari and S.S. Gill. 1988. Manual of Sugarcane Production in India. ICAR Publication, New Delhi.

AGRON 533

Agronomy of Kharif Pulses and Forage Crops

3(2+1)

Objective

To teach the crop husbandry of different forage crops and kharif pulses.

Theory

Origin, history, importance, distribution, adaptation, classifications, morphology, general production constraints, varietal improvement and production technology of mungbean, urdbean and mothbean, main and by products and their post harvest handling for marketing. Adaptation, distribution, varietal improvement; agrotechniques and quality aspects including anti quality factors of important fodder crops like berseem, lucerne, sorghum, oats and napier grass; year round fodder production and management, preservation and utilization of forage and pasture crops; principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage.

Practical

Phenological studies at different growth stages of crops, study of yield attributing characters of pulses ; computation of yield on the basis of yield attributing characters; study of morphology of root nodules in pulses; seed treatment of pulses and grain legumes with *Rhizobium* culture; interculture operations in various crops, seed treatment with fungicides for controlling soil and seed borne diseases; computation of cost of cultivation of various crops; calculation of fertilizer requirements and their application at different growth stages in various crops on the basis of soil test values, study of seed production techniques in various crops and visit to nearby fodder research farm. Method of propagation of napier grass; estimation of crude protein, crude fibre, crude fat, and NFE in forage crops; calculation of TDN, total digestible energy and metabolic energy in different forage crops.

Suggested Readings

- B.N. Chatterjee and K.K. Bhattacharya, 1986. Principles and Practices of Grain Legume Production, Oxford & IBH Publishing Company, New Delhi.
- B.N. Chatterjee and S. Maiti, 1982. Cropping systems (Theory and Practice), Oxford & IBH Publishing Co., New Delhi.
- B.N. Chatterjee and P.K. Das. 1989. Forage Crop Production – Principles and Practices, Oxford & IBH Publishing Co., New Delhi.
- B.N. Chatterjee and S. Maiti. 1978. Silage and hay making, ICAR, Publication, New Delhi.
- Chhidda Singh, Prem Singh and Rajbir Singh, 2003. Modern Techniques of Raising Field Crops. Oxford & IBH Publishing Co., New Delhi
- D.S. Yadav, 1992. Pulse Crops, Kalyani Publishers, New Delhi
- Das, N.R. 2007. Introduction to crops of India. Scientific Publisher, Jodhpur.
- Jeswani and Baldev, 1990. Advances in Pulse Production Technology, ICAR Pub., New Delhi.
- P.S. Rathore 2000. Techniques and Management of Field Crop Production Agrobios (India) Jodhpur
- Rajendra Prasad, 2002. Text book of field crops production ICAR Pub.
- S.C. Verma and M.P. Singh, 1987. Agronomy of New Plant Types, Text Book Agency, Varanasi.
- Mungbean, 1988. Proceedings of the second International symposium, AVRDC, Bangkok, Thailand, 16-20 Nov. 1987.
- S.S. Singh, 1988. Crop Management under Irrigated and Rainfed Conditions, Kalyani Publishers, New Delhi.

AGRON 534 Principles and Practices of Organic Farming

3(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 trees and trees 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 TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.
- Gaur AC. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document, FAO.
- Lampin N. 1990. *Organic Farming*. Press Books, Ipswich, UK.
- Palaniappan SP & Anandurai K. 1999. *Organic Farming – Theory and Practice*. Scientific Publ.
- Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, Parisaraprajna Parishtana, Bangalore.
- Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.
- Sharma A. 2002. *Hand Book of Organic Farming*. Agrobios.
- Singh SP. (Ed.) 1994. *Technology for Production of Natural Enemies*. PDBC, Bangalore.
- Subba Rao NS. 2002. *Soil Microbiology*. Oxford & IBH.
- Trivedi RN. 1993. *A Text Book of Environmental Sciences*, Anmol Publ.
- Veeresh GK, Shivashankar K & Suiglachar MA. 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

AGRON 535 Agronomy of Medicinal, Aromatic and Under-Utilized Crops 3(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.

UNIT II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, *Nux vomica*, Rosadale etc).

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, Clusterbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

Practical

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

Suggested Readings

Chadha KL & Gupta R. 1995. *Advances in Horticulture*. Vol. II. *Medicinal and Aromatic Plants*. Malhotra Publ.

Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.

Handa SS. 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. Abdul, Rangaswami JBM & Irulappan 1997. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford & IBH.

Prajapati ND, Purohit SS, Sharma AK & 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.

Ph.D Programme

AGRON 611

Advances in Crop Growth and Productivity

3(2+1)

Objective

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

Theory

Physiological limitations to crop yield- leaf area , photosynthesis, dry matter distribution; Solar radiation-concept, agro- techniques for harvesting solar radiation for crop yield ; Cardinal points of vital activities-Schimper`s optima, Hopkin`s Bioclimatic law ; Physiology of germination and seedling emergence - series/steps of germination; Concept of growth analysis- merits and de-merits , LAI, CGR, RGR, NAR, LAR, LAD ; Disadvantages of using leaf area as a basis of growth expression ; Types of growth curves-sigmoid, linear, parabolic and asymptotic ; Principles involved in mixed/inter cropping systems and related terminology, advantages and limitations; Heat unit concept of crop maturity- remainder index, degree days, physiological index and

interrelationship; Concept of plant ideotype; Regulation of growth and development of field crops; Bioenergetics of metabolic process.

Practical

Field measurement of root-shoot relationship in crops at different growth stages; Estimation of growth evaluating parameters like RGR, NAR, CGR, HI, LAI etc at different stages of crop growth, their correlation with final crop yield and interpretation thereof; Construction of crop growth curves on the basis of actual field data; Studying plant competition in intercropping system and calculations of LER, ; Theoretical computation of maximum crop productivity based on radiation receipt in the state; Correlation of crop growth with environmental parameters like temperature , sunshine, relative humidity and its interpretation; Calculation of heat unit requirement of important crops under various agro climatic conditions ; Analysis of productivity trends of important crops both under irrigated and dryland conditions on national and state level.

Suggested Readings

- A.L. Lehninger. 2006 . Biochemistry . Kalyani Publishers New -Delhi.
- B.N.Chatterjee and B.K. Mandal 1992. Present Trends in Research on Intercropping . *Indian J. Agric. Sci.* 62: 507-518.
- C.P. Wilsie. 1962. Crop Adaptation and Distribution, W.H. Freeman and Company, San Francisco and London.
- D.J. Watson. 1952. The physiological basis of variation in yield. *Advances in Agronomy Vol.4* American Society of Agronomy. Academic Press . Inc. Publishers, New York USA.
- G.Singh, J.S. Kolar and H.S. Sekhon 2002. Recent advances in Agronomy. Indian Society of Agronomy, IARI, New-Delhi.
- K.H.W. Klages 1968. Ecological crops geography. The Macmillan Co. New York, USA.
- L.T. Evans. 1975. Crop Physiology, Cambridge University Press, London, U.K.
- P.J. Redford . 1967. Growth Analysis Formulae : Their Use and Abuse, *Crop Science* 7:171-175.
- R.L.Yadav, Punjab Singh , R. Prasad and IPS Ahlawat 1998. Fifty Years of Agronomy Research in India ,Indian Society of Agronomy IARI , New-Delhi.
- R.M. Delvin and F.H. Witham. 1986. Plant Physiology . CBS Publishers and Distributors, New-Delhi.
- R.W. Willey and S.B. Heath. 1969. Quantitative relationship between plant population and crop yield . *Advances in Agronomy Vol.4* American Society of Agronomy. Academic Press . Inc. Publishers, New York USA
- R.W. Willey. 1979. Intercropping –its importance and research needs Part-I . *Field Crop Abstract*, CAB, Publication , England, 32-1-9
- S.C.Verma and M.P.Singh. 1987. Agronomy of New Plant Types. Tara Book Company, Varanasi.
- Scott Russel . 1982. Plant Root Systems, Mc GrawHill Book Company, England.
- U.S. Gupta, (Ed.) 1995. Production and Improvement of Crops for Drylands. Oxford & IBH, New Delhi
- U.S. Gupta, 1988. Progress in Crop Physiology. Oxford and IBH Publishing Co., New-Delhi.
- U.S.Gupta. 1979. Physiological Aspects of Dryland Farming (Ed) Oxford and IBH Publishing Co., New-Delhi.
- Z. Sastak, J. Catsky, and P.G. Jarvis. 1971. Plant photosynthetic Production, Manual of Methods, W. Junk, N. V. Publication.

AGRON 612**Advances in Weed Management****3(3+0)****Objective**

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

Theory

Weed crop competition in different cropping situations, changes in weed flora, various causes and effects. Absorption, translocation and action of herbicides in plants. Fate of herbicides in plants and soils and factors affecting them, selectivity of herbicides and factors affecting herbicide and environment interaction, residue management of herbicides, adjuvants, advances in herbicide application techniques, herbicide resistance and their remedial measures; Compatibility of herbicides with other pesticides, synergism and antagonism in herbicides, development of transgenic herbicide resistant crops, relationship of herbicides with tillage, fertilizer and irrigation, bio-herbicide approach in weed management.

Suggested Readings

- Gupta O.P. 2000. Modern Weed Management, Agrobios Publishers.
Gupta O.P. 2007. Weed Management, Principles and Practices, Agrobios
Rao V.S. 2007. Principles of Weed Science, Oxford & IBH
Zimdahl R.L. 1999. Fundamentals of Weed Sciences 2nd Ed. Academic Press.
Devine, Duke and Fedtke. 1988. Physiology of Herbicide action
U.S. Walia, 1990. Weed management, Kalyani Publishers, New Delhi.
Saraswat V.N., Bhan V.M. & Yaduraju N.T., 2003. Weed Management, ICAR
Streibig J.C. and Kudsk P. 1993. Herbicide Bioassays, CRC Press Inc.
Naylor R.E.L. 2002. Weed Management Blackwell Publishing Co.

AGRON 613**Crop Ecology****3(3+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, principles of plant distribution and adaptation, crop and world food supply.

UNIT II

Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept.

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 solar energy in crops; vertical distribution of temperature; efficiency in crop production.

UNIT V

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

Suggested Readings

- Ambasht RS. 1986. *A Text Book of Plant Ecology*. 9th Ed. Students' Friends & Co. 74
- Chadha KL & Swaminathan MS. 2006. *Environment and Agriculture*. Malhotra Publ. House.
- Dwivedi P, Dwivedi SK & Kalita MC. 2007. *Biodiversity and Environmental Biotechnology*. Scientific Publ.
- 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.

AGRON 621

Irrigation Management

3(2+1)

Objective

To teach students about optimization of irrigation in different crops under variable agroclimatic conditions.

Theory

Water resources of India, irrigation projects, irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need, water deficits and crop growth. Soil plant water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity. Infiltration, water movement under saturated and unsaturated conditions, management practices for improving water use efficiency of crops. 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. Strategies of using limited water supply, factors affecting ET, control of ET by mulching and use of antitranspirants. Fertilizer use in relation to irrigation, optimising the use of given irrigation supplies. Land suitability for irrigation, land irrigability classification, integrated water management in command areas, institution of water management in commands, Farmer's participation in command areas, irrigation legislation.

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. Use of sensors in irrigation scheduling. Determination of uniformity coefficients for sprinkler irrigation system. Evaluation of different methods of irrigation. Agronomic evaluation of irrigation projects, case studies.

Suggested Readings

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

- Majumdar, D.K. 2004. *Irrigation Water Management: Principles and Practice*. Prentice Hall of India, New Delhi.
- Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
- Mishra RR & Ahmad M. 1987. *Manual on Irrigation Agronomy*. Oxford & IBH.
- Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Sankara Reddy GH & Yellamananda Reddy 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.
- Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.

AGRON 622

Stress Crop Production

3(2+1)

Objective

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

Theory

Stress and strain terminology; nature of stress injury and resistance; causes of stress; low temperature; viz., chilling and freezing injury and resistance; high temperature or heat stress injury and resistance; water stress viz; water deficit, excess water or flooding stresses injury and resistance; salt stress and its effect on plant growth, stress injury and resistance; practical ways of overcoming various stresses through soil and crop manipulations; environmental pollution viz. air, soil and water and their effect on crop growth and quality.

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 and in artificially salinized soil in pots for biochemical and physiological studies; effect of drought and salt stress on plant growth; effect of osmotic and ionic stress on seed germination and seedling growth, fertilizer management under water and salt stress conditions; study of low temperature injury under field conditions.

Suggested Readings

- Baker FWG. 1989. *Drought Resistance in Cereals*. Oxon, UK.
- Gupta U.S. (Ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.
- Kramer PJ. 1983. *Water Relations of Plants*. Academic Press.
- Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.
- Mavi HS. 1994. *Introduction to Agro-meteorology*. Oxford & IBH.
- Nilsen ET & Orcut DM. 1996. *Physiology of Plants under Stress – Abiotic Factors*. John Wiley & Sons.
- Singh K. 2000. *Plant Productivity under Environmental Stress*. Agrobios.
- Somani LL & Totawat KL. 1992. *Management of Salt-affected Soils and Waters*. Agrotech Publ.
- Virmani SM, Katyal JC, Eswaran H & Abrol IP. 1994. *Stressed Ecosystem and Sustainable Agriculture*. Oxford & IBH.

AGRON 623

Soil Conservation and Watershed Management

3(2+1)

Objective

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

Theory

UNIT I

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting 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, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

UNIT III

Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

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.

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. Identification of different grasses and trees for soil conservation. Visit to a soil conservation research centre, demonstration and training centre.

Suggested Readings

Arakeri HR & Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.

Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.

FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas*. *Soils Bull.*, Paper 57.

Frederick RT, Hobbs J, Arthur D & Roy L. 1999. *Soil and Water Conservation: Productivity and Environment Protection*. 3rd Ed. Prentice Hall.

Gurmel Singh, Venkataraman CG, Sastry B & Joshi P. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

Murthy VVN. 1995. *Land and Water Management Engineering*. Kalyani.

Tripathi RP & Singh HP. 1993. *Soil Erosion and Conservation*. Wiley Eastern.

Yellamanda Reddy T & Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

AGRON 624

Current Trends in Agronomy

3(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 soilplant-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.

AGRON 625 Integrated Farming Systems

3(3+0)

Objective

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

Theory

UNIT I

Farming systems: definition and importance; 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

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems.

UNIT V

New concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

Suggested Readings

- Ananthakrishnan TN. (Ed.) 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.
- Balasubramanian P & Palaniappan SP 2006. *Principles and Practices of Agronomy*. Agrobios.
- Joshi M & Parbhakarasetty TK. 2005. *Sustainability through Organic Farming*. Kalyani.
- Lampin N. 1990. *Organic Farming*. Farming Press Books.
- Palaniappan SP & Anandurai K. 1999. *Organic Farming - Theory and Practice*. Scientific Publ.
- Panda SC. 2004. *Cropping systems and Farming Systems*. Agribios.
- Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.
- Sharma AK. 2001. *A Hand Book of Organic Farming*. Agrobios.
- Singh SP. (Ed) 1994. *Technology for Production of Natural Enemies*. PDBC, Bangalore.
- Trivedi RN. 1993. *A Text Book of Environmental Sciences*. Anmol Publ.
- Veeresh GK, Shivashankar K & Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture*. Association for Promotion of Organic Farming, Bangalore.

AGRON 626 Crop Production and System Modeling

3(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 MJ & Vann Laar HH. (Ed.). 1993. *Modelling Crop Weed Interactions*. ISBN.
- Mathews RB, Kropff MJ, Bachelet D & Vaan Laar HH. (Eds.). 1993. *Modelling the Impact of Climate Change on Rice Production in Asia*. CABI.

Penning de Vries FWT & Van Laar HH. (Eds.). 1982. *Simulation of Plant Growth and Crop Production*. Wageningen Centre for Agricultural Publications and Documentation, Netherlands.

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

Zeigler BP. 1976. *Theory of Modeling and Simulation*. John Wiley & Sons.

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 Sciences
- Nutrient Cycling in Agro ecosystem
- Pesticide Biochemistry and Physiology
- Plant and Soil
- Plant Production Science
- Soil and Tillage Research
- Swedish Journal of Agricultural Research
- Tropical Agriculture
- Weed Research

SOIL SCIENCE

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	SOILS-511*	SOIL CHEMISTRY	3(2+1)
2.	SOILS -512	SOIL MINERALOGY,GENESIS, CLASSIFICATION AND SOIL SURVEY	3(2+1)
3	SOILS -513	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	3(1+2)
4	SOILS -514	RADIOISOTOPS IN SOIL AND PLANT STUDIES	2(1+1)
II-Semester			
5.	SOILS -521*	SOIL FERTILITY AND FERTILIZER USE	4(3+1)
6.	SOILS -522*	SOIL BIOLOGY AND BIOCHEMISTRY	3(2+1)
7.	SOILS -523	REMOTE SENSING AND GIS TECHNIQUES FOR SOIL AND CROP STUDIES	2(2+0)
8.	SOILS -524	SOIL,WATER AND AIR POLLUTION	3(2+1)
9.	SOILS -525	FERTILIZER TECHNOLOGY	2(2+0)
10.	SOILS -526	GEOMORPHOLOGY AND GEOCHEMISTRY	3(2+1)
III-Semester			
11.	SOILS -531*	SOIL PHYSICS	3(2+1)
12.	SOILS -532	MANAGEMENT OF PROBLAM SOILS AND WATERS	3(2+1)
13.	SOILS -533	SOIL EROSION AND CONSERVATION	3(2+1)
14.	SOILS -534	LAND DEGRADATION AND RESTORATION	3(2+1)
15.	SOILS -535	SYSTEM APPROCHES IN SOIL AND CROP STUDIES	3(2+1)
IV-Semester			
16.	SOILS -541	SEMINAR	1
17.	SOILS -542	COMPREHENSIVE	2
18.	SOILS -543	RESEARCH	15
Ph.D.			
I-Semester			
1.	SOILS -611*	ADVANCES IN SOIL FERTILITY	3(2+1)
2	SOILS -612	ADVANCES IN SOIL PHYSICS	3(3+0)
3	SOILS -613	PHYSICAL CHEMISTRY OF SOILS	3(3+0)
II-Semester			
4.	SOILS -621*	BIOCHEMISTRY OF SOIL ORGANIC MATTER	3(2+1)
5	SOILS -622	CLAY MINERALOGY	3(3+0)
6	SOILS -623	LAND USE PLANNING AND WATERSHED MANAGEMENT	3(3+0)
7	SOILS -624	SOIL GENESIS AND MICROPEDOLOGY	2(2+0)
III and onward Semesters			
	SOILS -641	SEMINAR	2
	SOILS -642	PRELIMENRY	4
	SOILS -643	RESEARCH	40

***Core courses**

SOIL SCIENCE

M.Sc(Ag) Programme

SOILS 511

Soil Chemistry

3(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.

Theory

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: inorganic and organic colloids - 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; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions.

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; 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; 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; sub-soil acidity.

UNIT VII

Chemistry of salt-affected soils 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, E_h by the use of E_h -pH meter and conductivity meter. Adsorption-desorption of

phosphate/sulphate by soil using simple. Adsorption isotherm. Determination of titratable acidity of an acid soil by BaCl₂-TEA method.

Suggested Readings

- Bear R.E. 1964. *Chemistry of the Soil*. Oxford and IBH.
Bolt G.H & Bruggenwert M.G.M. 1978. *Soil Chemistry*. Elsevier.
Greenland D.J & Hayes M.H.B. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
McBride M.B. 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 F.J. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 512 Soil Mineralogy, Genesis, Classification and Survey 3(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, isomorphism and polymorphism.

UNIT II

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

UNIT III

Soil morphology and micromorphology, Factors of soil formation, soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

UNIT IV

Concept of soil individual; soil classification systems – 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; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; 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 with special reference to respective states; 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 of rocks and minerals. Morphological properties of soil profile in different landforms. Classification of soils using soil taxonomy. Grouping soils using available

Suggested Readings

- SOILS 513 Analytical Techniques and Instrumental Methods in Soil and Plant Analysis 3(1+2)**

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.

Principles of visible, ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractometry; identification of minerals by X-ray by different methods.

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.

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Electrochemical titration of clays; determination of cation and anion exchange capacities of soils; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods.

UNIT V

Drawing normalized exchange isotherms; measurement of redox potential.

Suggested Readings

Hesse P. 1971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.

Jackson M.L. 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 A.L, Miller R.H & Keeney D.R. 1982. *Methods of Soil Analysis*. Part II.SSSA, Madison.

Piper C.E. *Soil and Plant Analysis*. Hans Publ.

Singh D, Chhonkar PK & Pandey RN. 1999. *Soil Plant Water Analysis – A Methods 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 Waters*. FDCO, New Delhi.

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

SOILS 514

Radioisotopes in Soil and Plant Studies

2(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 ^{32}P / ^{65}Zn . Use of neutron probe for moisture determination. Sample preparation and measurement of ^{15}N enrichment by mass. Spectrophotometry/ 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.

SOILS 521

Soil Fertility and Fertilizer Use

4(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.

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

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

Practical

Chemical analysis of soil for total N, P & K and available nutrients (N, P, K, S, Cu, Fe, Mn, Zn, Mo, B). Analysis of plants for essential elements (N, P, K, S, Cu, Fe, Mn, Zn, Mo, B)

Suggested Readings

- Brady N.C & Weil R.R. 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. *Biofertilizers Technology*. Scientific Publ.
- Leigh J.G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K & Kirkby E.A. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt J.J, Shuman L.M, Cox F.R & Welch R.M. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.
- Pierzinsky G.M, Sims T.J & Vance J.F. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.
- Stevenson F.J & Cole M.A. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale S.L, Nelson S.L, Beaton J.D & Havlin J.L. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.
- Troeh F.R & Thompson L.M. 2005. *Soils and Soil Fertility*. Blackwell.

SOILS 522

Soil Biology and Biochemistry

3(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; rhizosphere, 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

Biodegradation of 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, BIS standards for biofertilizer for quality control

Practical

Determination of soil microbial population. Soil microbial biomass (C N P). Fractionation of organic matter (HA, FA, Humin, Lignin and humus) and functional groups. Soil enzymes. Measurement of important soil microbial processes such as nitrification, N₂ fixation, S oxidation, P solubilization

Suggested Readings

- Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.
- Burges A & Raw F. 1967. *Soil Biology*. Academic Press.
- McLaren A.D & Peterson G.H. 1967. *Soil Biochemistry*. Vol. XI. Marcel Dekker.
- Metting F.B. 1993. *Soil Microbial Ecology – Applications in Agricultural and Environmental Management*. Marcel Dekker.
- Paul E.A & Ladd J.N. 1981. *Soil Biochemistry*. Marcel Dekker.
- Reddy M.V. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.
- Russel R.S. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill.
- Stotzky G & Bollag J.M. 1993. *Soil Biochemistry*. Vol. VIII. Marcel Dekker.
- Sylvia D.N. 2005. *Principles and Applications of Soil Microbiology*. Pearson Edu.
- Wild A. 1993. *Soil and the Environment - An Introduction*. Cambridge Univ. Press.

SOILS 523 Remote Sensing and GIS Techniques for Soil, Water and Crop Studies

2(2+0)

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.

UNIT II

Sensor systems - camera, microwave radiometers and scanners; 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, remote sensing applications in monitoring and management of soil and water pollution.

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.

UNIT V

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

Suggested Readings

- Brady N.C & Weil R.R. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.
- Lillesand T.M & Kiefer R.W. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.
- Nielsen D.R & Wendroth O. 2003. *Spatial and Temporal Statistics*. Catena Verlag GmbH.
- Star J & Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

SOILS 524**Soil, Water and Air Pollution****3(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.

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; soil as a sink for waste disposal, soil and water quality standards.

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 ammonical nitrogen and phosphorus, heavy metal content in effluents. Heavy metals in contaminated soils and plants. Analysis of soil and plant samples for pesticides residues. Visit to various industrial sites to study the impact of pollutants on soil and plants.

Suggested Readings

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

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

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

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

SOILS 525**Fertilizer Technology****2(2+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; fertilizer control order.

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 and fertilizers for specific crops/situations.

Suggested Readings

Brady N.C & Weil R.R. 2002. *The Nature and Properties of Soils*. Pearson. Edu.

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

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

Olson R.A, Army T.S, Hanway J.J & Kilmer V.J. 1971. *Fertilizer Technology and Use*. 2nd Ed. Soil Sci. Soc. Am. Madison.

Prasad R & Power J.F. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Tisdale S.L, Nelson S.L, Beaton J.D & Havlin J.L. 1999. *Soil Fertility and Fertilizers*. McMillan Publ.

Vogel A.I. 1979. *Textbook of Quantitative Inorganic Analysis*. ELBS.

SOILS 526

Geomorphology and Geochemistry

2(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 P.W. 1999. *Soils and Geomorphology*. 3rd Ed. Oxford Univ. Press.

Likens G.E & Bormann F.H. 1995. *Geochemistry*. 2nd Ed. Springer Verlag.

Mortvedt J.J, Shuman L.M, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

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 continuum.

UNIT IX

Composition of soil air; 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. Determination of bulk density of soil by core sampler method. 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. Estimation of water balance components in bare and cropped fields

Suggested Readings

Baver L.D, Gardner W.H & Gardner W.R. 1972. *Soil Physics*. John Wiley & Sons.
Ghildyal B.P & Tripathi R.P. 2001. *Soil Physics*. New Age International.

- Hanks J.R. & Ashcroft G.L. 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 Physics*. 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 W.L. 1972. *Advanced Soil Physics*. Wiley-Interscience.
- Kohnke H. 1968. *Soil Physics*. McGraw Hill.
- Lal R & Shukla M.K. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal M.C. 1994. *Soil Physics*. Oxford & IBH.
- Saha A.K. 2004. *Text Book of Soil Physics*. Kalyani.

SOILS 532

Management of Problem Soils and Waters

3(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; management of acid soils; 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^- , SO_4^{--} , CO_3^{--} and HCO_3^-) in ground waters and soil samples. Lime requirements of acid soil and gypsum requirements of sodic soil.

Suggested Readings

Bear F.E. 1964. *Chemistry of the Soil*. Oxford & IBH.

Jurinak J.J. 1978. *Salt-affected Soils*. Deptt. of Soil Science & Biometeorology. Utah State Univ.
 USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.

SOILS 533

Soil Erosion and Conservation

3(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 T.D & Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.

Doran J.W & Jones A.J. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.

Gurmal Singh, Venkataramanan C, Sastry G & Joshi B.P. 1990. *Manual of Soil 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 M.C. 1994. *Soil Physics*. Oxford & IBH.

SOILS 534**Land Degradation and Restoration****3(2+1)****Objective**

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

Theory**UNIT I**

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

UNIT II

Soil health, indicators for determining soil health, soil quality management and sustainability.

UNIT III

Soil sickness and clinical approaches for sustainable agriculture

UNIT IV

Soil physical environment, alleviation of soil physical constraints for sustainable crop production

UNIT V

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

UNIT VI

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.

Practical

Soil and water sampling over adjoining to mining industries. Analysis of effluents for different heavy metals. Observations, examinations and identification of plant for diagnostic techniques for micronutrients and development of guide for plant diagnosis. Assessment of degraded lands by GIS techniques. Assessment of soil loss by water erosion. Assessment of soil loss by wind erosion.

Suggested Readings

Biswas T D & Narayanasamy G. (Eds.). 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Soc. Soil Sci. 17, New Delhi.

Doran J.W & Jones A.J. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.

Greenland D.J & Szabolcs I. 1994. *Soil Resilience and Sustainable Land Use*. CABI.

Lal R, Blum W.E.H, Vailentine C & Stewart B.A. 1997. *Methods for assessment of Soil Degradation*. CRC Press.

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

SOILS 535**System Approaches in Soil and Crop Studies****3(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 D.K & Nieder R. (Eds.). 2003. *Handbook of Processes and Modelling in the Soil - Plant System*. Haworth Press.

Hanks J & Ritchie J.T. (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 G.Y, 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.

Ph. D Programme

SOILS 611

Advances in Soil Fertility

3(2+1)

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 equilibria) 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.

Practical

Determination of Q / I relationship of P and K. Determination of cations exchange capacity of roots-cereals and legume. Study of mobility of nutrients and metallic cations in soil columns. Incubation studies on the solubilization of rock phosphates using chemical and biological agents. Determination of phosphate potential in soil.

Suggested Readings

Barber S.A. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.

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

Brady N.C & Weil R.R. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Educ.

Cooke G.W. 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 Technology*. Scientific Publ.

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

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

Stevenson F.J & Cole M.A. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.

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

Tisdale SL, Nelson W.L, Beaton J.D & Havlin J.L. 1990. *Soil Fertility and Fertilizers*. 5th Ed. Macmillan Publ.

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

SOILS 612

Advances in Soil Physics

3(3+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, Poiseuille's 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 agriculture.

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 L.D, Gardner W.H & Gardner W.R. 1972. *Soil Physics*. John Wiley & Sons.
Hanks and Ascheroff. 1980. *Applied Soil Physics*. Springer Verlag.
Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
Hillel D. 1980. *Environmental Soil Physics*. Academic Press.
Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
Kirkham D & Powers W.L. 1972. *Advanced Soil Physics*. Wiley Interscience.
Lal R & Shukla M.K. 2004. *Principles of Soil Physics*. Marcel Dekker.
Oswal M.C.1994. *Soil Physics*. Oxford & IBH.

SOILS 613

Physical Chemistry of Soils

3(3+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 R.E. 1964. *Chemistry of the Soil*. Oxford & IBH.

Bolt G.H & Bruggenwert M.G.M. 1978. *Soil Chemistry*. Elsevier.

Fried M & Broeshart H. 1967. *Soil Plant System in Relation to Inorganic Nutrition*. Academic Press.

Greenland D.J & Hayes M.H.B. 1981. *Chemistry of Soil Processes*. John. Wiley & Sons.

Greenland D.J & Hayes M.H.B. 1978. *Chemistry of Soil Constituents*. John Wiley & Sons.

Jurinak J.J. 1978. *Chemistry of Aquatic Systems*. Dept. of Soil Science & Biometeorology, Utah State Univ.

McBride M.B. 1994. *Environmental Chemistry of Soils*. Oxford Univ. Press.

Sparks D.L. 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 F.J. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.

van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 621

Biochemistry of Soil Organic Matter

3(2+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

Determination of soil organic carbon by dry combustion, rapid titration and colorimetric methods. Fractionations of soil organic matter (HA,FA,Humin,Lignin and Humus). Estimation of humic, humic acid, β humus and fulvic acid. Determination of CEC and functional group of humic substances. Elemental composition of organic matter.

Suggested Readings

Beck A.J, Jones K.C, Hayes M.H.B & Mingelgrin U. 1993. *Organic Substances in Soil and Water: Natural Constituents and their Influences on Contaminant Behavior*. Royal Society of Chemistry, London.

Gieseking J.E. 1975. *Soil Components*. Vol. 1. *Organic Components*. Springer-Verlag.

Kristiansen P, Taji A & Reganold J. 2006. *Organic Agriculture: A Global Perspective*. CSIRO Publ.

Magdoff .F & Weil R.R 2004. *Soil Organic Matter in Sustainable Agriculture*. CRC Press.

Mercky R & Mulongoy K. 1991. *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture*. John Wiley & Sons.

Paul E.A. 1996. *Soil Microbiology and Biochemistry*. Academic Press.

Stevenson F.J. 1994. *Humus Chemistry – Genesis, Composition and Reactions*. John Wiley & Sons.

SOILS 622

Clay Mineralogy

3(3+0)

Objective To impart knowledge about modern concepts of clays, with emphasis on understanding the processes involved with practical significance

Theory

UNIT I

Clay minerals: Classification and distribution Classification of clay minerals, Properties, structure and morphology of clay minerals, Distribution of clay minerals in different soil taxonomic orders in Indian soils, Clay minerals of Rajasthan soils

UNIT II

Origin and occurrence of clay minerals, Weathering and soil clays, Stability of minerals and factors in determining relative stability of minerals, Genesis of clay minerals (Detrital inheritance, transformation & synthesis), Clay formation in relation to factors affecting soil profiles

UNIT III

Soil clay mineralogy and nutrient availability, Potassium, phosphorus and nitrogen, Micronutrient elements

UNIT IV

Clay water system, Cataphoresis and zeta potential, Kinetics of coagulation, Viscosity and swelling of clay water systems

UNIT V

Interaction of clay minerals with organic compounds: Reaction with different types of clay minerals (montmorillonite, halloysite, kaolinite, illite, chlorite, vermiculite and attapulgite)

UNIT VI

Identification and quantification of clay minerals, Methods based on crystal structure Methods based on thermal properties, shape and size. Methods based on physicochemical and chemical properties and other properties, Infrared spectral analysis, optical microscopic study and staining tests of clay minerals

Suggested Readings

R.E. Grim, 1953. Clay Mineralogy. McGraw-Hill Book Co., New York.
 F.E. Bear. 1964. Chemistry of the Soil. Oxford and IBH Publishing Co., New Delhi.
 Srikankas, John. 1969. Mineralogy. A. First Course Affiliated East-West Pres Pvt. Ltd. New Delhi.
 Indian Soc. Soil Sci. 2002. Fundamental of Soil Science Cambridge Printing Works, New Delhi.

SOILS 623 Land Use Planning and Watershed Management 3(3+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 J.L, Mandal D.K, 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.

SOILS 624 Soil Genesis and Micropedology 3(3+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 S.W, Hole E..D, MacCraken R.J & Southard R.J. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.

Brewer R. 1976. *Fabric and Mineral Analysis of Soils*. John Wiley & Sons.

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

HORTICULTURE

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	HORT. 511	TROPICAL AND DRY LAND HORTICULTURE	3 (2+1)
2.	HORT. 512	SUB-TROPICAL AND TEMPERATE FRUIT PRODUCTION	3 (2+1)
3	HORT. 513	PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS	3 (2+1)
II- Semester			
5.	HORT. 521	SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS	3 (2+1)
6.	HORT. 522	PROPAGATION AND NURSERY MANAGEMENT OF FRUIT CROPS	3 (2+1)
7.	HORT. 523	PRODUCTION TECHNOLOGY OF CUT FLOWERS	3 (2+1)
8.	HORT. 524	PRODUCTION TECHNOLOGY OF SPICES CROPS	3 (2+1)
9.	HORT. 525	BREEDING OF VEGETABLE CROPS	3 (2+1)
10.	HORT. 526	BIOTECHNOLOGY OF HORTICULTURAL CROPS	3 (2+1)
11.	HORT. 527	PRODUCTION TECHNOLOGY OF LOOSE FLOWERS	3 (2+1)
12.	HORT. 528	PRODUCTION TECHNOLOGY OF UNDER EXPLOITED VEGETABLE CROPS	3 (2+1)
III- Semester			
13.	HORT. 531	LANDSCAPING AND ORNAMENTAL GARDENING	3 (2+1)
14.	HORT. 532	POST HARVEST TECHNOLOGY FOR FRUIT CROPS	3 (2+1)
15.	HORT. 533	PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS	3 (2+1)
IV- Semester			
16.	HORT. 541	SEMINAR	1
17.	HORT. 542	COMPREHENSIVE	2
18.	HORT. 543	RESEARCH	15
Ph.D.			
I- Semester			
1.	HORT. 611	BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS	3 (2+1)
2	HORT. 612	BIOTECHNOLOGY OF HORTICULTURAL CROPS	3 (2+1)
3	HORT. 613	ADVANCES IN BREEDING OF FRUIT CROPS	3 (2+1)
4.	HORT. 614	ADVANCES IN BREEDING OF VEGETABLE CROPS	3 (2+1)
5	HORT. 615	ADVANCES IN BREEDING OF FLOWER CROPS	3 (2+1)
II- Semester			
6	HORT. 621	ADVANCES IN PRODUCTION OF FRUIT CROPS	3 (2+1)
7	HORT. 622	ADVANCES IN VEGETABLE PRODUCTION	3 (2+1)
8	HORT. 623	PROTECTED CULTIVATION OF VEGETABLE CROPS	3 (2+1)
9	HORT. 624	ADVANCES IN FLOWER PRODUCTION	3 (2+1)
10	HORT. 625	PROTECTED CULTIVATION OF FLOWER CROPS	3 (2+1)
III- and onward semesters			
11.	HORT. 641	SEMINAR	2
12.	HORT. 642	PRELIMENRY	4
13.	HORT. 643	RESEARCH	40

HORTICULTURE

M.Sc. (Ag) Programme

HORT 511

Tropical and Dry Land Fruit Production

3(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 bio regulators, 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:	Papaya, Coconut and Cashew nut
UNIT III:	Sapota and Jackfruit
UNIT IV:	Pineapple and Annonas
UNIT V:	Aonla, Pomegranate, Phalsa and Ber, minor fruits of tropics (Mahua, Lasoda, Mulberry, Tamarind and Chironji)

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, Practices of important agro-techniques, 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, T.K, Mitra, S.K & Sanyal, D. 2001. (Eds.). *Fruits -Tropical and Subtropical*. Naya Udyog.
- Chadha, K.L & Pareek, O.P. 1996. (Eds.). *Advances in Horticulture*. Vols. II- IV. Malhotra Publ. House.
- Nakasone, H.Y & Paul, R.E. 1998. *Tropical Fruits*. CABI.
- Peter, K.V. 2008. (Ed.). *Basics of Horticulture*. New India Publ. Agency.
- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan, K.N. 2008. *Management of Horticultural Crops*. Parts I, II. New India Publ. Agency.
- Radha, T & Mathew, L. 2007. *Fruit Crops*. New India Publ. Agency.
- Singh, H.P, Negi JP & Samuel JC. (Eds.). 2002. *Approaches for Sustainable*

Development of Horticulture. National Horticultural Board.
Singh, H.P., Singh G, Samuel, J.C & Pathak R.K. (Eds.). 2003. *Precision Farming in Horticulture*. NCPAH, DAC/PFDC, CISH, Lucknow.

HORT 512 Subtropical and Temperate Fruit Production 3 (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, bio regulation, 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, pre-cooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support.

Crops

UNIT I:	Apple, pear, quince
UNIT II:	Plums, peach, apricot, cherries
UNIT III:	Litchi, loquat, kiwifruit, strawberry
UNIT IV:	Nuts- walnut, almond, pistachio
UNIT V:	Grapes, Guava, Citrus and Custard apple
UNIT VI:	Minor fruits- carambola, bael, wood apple, fig, jamun, rambutan, ker, pilu

Practical

Identification of important fruit plants and its available 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 T.K, Mitra S.K & Sanyal D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*. 3rd Ed. Vols. I, II. Naya Udyog.
Chadha K.L & Pareek O.P. 1996. (Eds.). *Advances in Horticulture*. Vol. I. Malhotra Publ. House.
Chadha K.L & Shikhamany S.D. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House.
Janick J & Moore J.N. 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 V.J, Srivastava A.K & Singh I.P. (Eds.). 2004. *Advances in Citriculture*. Jagmander Book Agency.

HORT 513 Production Technology of Warm Season Vegetable Crops 3(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	Colocasia 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 T.K & Som M.G. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.
- Bose T.K, Kabir J, Maity T.K, Parthasarathy V.A & Som M.G. 2003. *Vegetable Crops*. vols. I-III. Naya Udyog.
- Bose T.K, Som M.G & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.
- Brown H.D & Hutchison C.S. *Vegetable Science*. JB Lippincott Co.
- Chadha K.L & Kalloo G. (Eds.). 1993-94. *Advances in Horticulture*. vols. V-X. Malhotra Publ. House.
- Chadha K.L. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.
- Chauhan D.V.S. (Ed.). 1986. *Vegetable Production in India*. Ram Prasad & Sons.
- Decoteau D.R. 2000. *Vegetable Crops*. Prentice Hall.
- Edmond J.B, Musser A.M & Andrews F.S. 1964. *Fundamentals of Horticulture*. Blakiston Co
- Fageria M.S, Choudhary B.R & Dhaka R.S. 2000. *Vegetable Crops: Production Technology*. vol. II. Kalyani.
- Gopalakrishanan T.R. 2007. *Vegetable Crops*. New India Publ. Agency.
- Hazra P & Som M.G. (Eds.). 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.
- Kaloo G & Singh K (Ed.). 2000. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals & Book Publ. House.
- Nayer N.M & More TA 1998. *Cucurbits*. Oxford & IBH Publ.
- Palaniswamy & Peter Ky. 2007. *Tuber Crops*. New India Publ. Agency.
- Pandey A.K & Mudranalay y. (Eds.). *Vegetable Production in India: Important Varieties and Development Techniques*.
- Rana M.K. 2008. *Olericulture in India*. Kalyani.
- Rana M.K. 2008. *Scientific Cultivation of Vegetables*. Kalyani.
- Rubatzky V.E & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.
- Saini G.S. 2001. *A Text Book of Oleri and Flori Culture*. Aman Publ. House.
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- Singh D.K. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.
- Singh N.P, Bharadwaj A.K, Kumar A & Singh K.M. 2004. *Modern Technology on Vegetable Production*. International Book Distributing Co.
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- Thamburaj S & Singh N. 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
- Thompson H.C & Kelly W.C. (Eds.). 1978. *Vegetable Crops*. Tata Mc Graw Hill.

HORT 521 Seed Production Technology of Vegetable Crops 3(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 IV

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.

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 P.K & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.
- Agrawal R.L. (Ed.). 1997. *Seed Technology*. Oxford & IBH.
- Bendell P.E. (Ed.). 1998. *Seed Science and Technology: Indian Forestry Species*.

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Fageria M.S, Arya P.S & Choudhary A.K. 2000. *Vegetable Crops: Breeding and Seed Production*. vol. I. Kalyani.

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Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.

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Rajan S & Baby L Markose. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.

Singh N.P, Singh D.K, Singh Y.K & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distributing Co.

Singh S.P. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.

HORT 522 Propagation and Nursery Management for Fruit Crops 3(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 cuttings. 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 V

Micro-propagation– principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micro grafting, meristem culture. Hardening, packing and transport of micro-propagules, shoot tip grafting/ micro grafting.

UNIT VI

Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagation production.

Practical

Preparation and planting of cuttings and layering, Root stock raising, Practices of different methods of budding and grafting, Study of media and PGR. Hardening, 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 H.T & Kester D.E. 1989. *Plant Propagation – Principles and Practices*. Prentice Hall of India.
- Bose T.K, Mitra S.K & Sadhu M.K. 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.

HORT 523

Production Technology of Cut Flowers

3(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 CO₂ on growth and flowering.

UNIT III

Flower production – water and nutrient management, fertigation, weed management, 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: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, lilioms, bird of paradise, heliconia, bromeliads, dahlia, gypsophilla, statice, 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 J.S. 2006. *Introductory Ornamental horticulture*. Kalyani.
- Bhattacharjee S.K. 2006. *Advances in Ornamental Horticulture*. vols. I-VI. Pointer

Publ.

Bose T.K & Yadav L.P. 1989. *Commercial Flowers*. Naya Prakash.

Bose T.K, Maiti R.G, Dhua R.S & Das P. 1999. *Floriculture and Landscaping*. Naya Prakash.

Chadha K.L & Chaudhury B. 1992. *Ornamental Horticulture in India*. ICAR.

Chadha K.L. 1995. *Advances in Horticulture*. vol. XII. Malhotra Publ. House.

Lauria A & Ries V.H. 2001. *Floriculture – Fundamentals and Practices*. Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture*. Agrobios.

Randhawa G.S & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra R.L. 2007. *High tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.

HORT 524

Production Technology of Spice Crops

3(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 seed 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 E.V.D & Sharma R.K. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ.

Arya PS. 2003. *Spice Crops of India*. Kalyani.

Bhattacharjee S.K. 2000. *Hand Book of Aromatic Plants*. Pointer Publ.

Bose T.K, Mitra S.K, Farooqi S.K & Sadhu M.K (Eds.). 1999. *Tropical Horticulture*. vol.I. Naya Prakash.

Chadha K.L & 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 N.A, Khader P, Rangaswami & Irulappan I. 2000. *Introduction to Spices*,

Plantation Crops, Medicinal and Aromatic Plants. Oxford & IBH.

Nybe E.V, Miniraj N & Peter K.V. 2007. *Spices*. New India Publ. Agency. Parthasarthy VA, Kandiannan V & Srinivasan V. 2008. *Organic Spices*. New India Publ. Agency.

Peter K.V. 2001. *Hand Book of Herbs and Spices*. vols. I-III. Woodhead Publ. Co. UK and CRC USA

Pruthi J.S. (Ed.). 1998. *Spices and Condiments*. National Book Trust

Pruthi J.S. 2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*. ICAR.

Purseglove J.W, Brown E.G, Green C.L & Robbins S.R.J. (Eds.). 1981. *Spices*. vols. I, II. Longman.

Shanmugavelu K.G, Kumar N & Peter K.V. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.

Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Tiwari R.S & Agarwal A. 2004. *Production Technology of Spices*. International Book Distr. Co.

Yarmudy V. 2001. *Marketing of Spices*. Daya Publ. House.

HORT 525

Breeding of Vegetable Crops

3(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 and lettuce
UNIT IV	Gourds, melons, pumpkins and squashes
UNIT V	Cabbage, cauliflower, carrot, beetroot, radish and sweet potato

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 tress 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.
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- Kaloo G. 1988. *Vegetable Breeding*. vols. I-III. CRC Press.
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- Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.
- Paroda RS & Kaloo G. (Eds.). 1995. *Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Region*. 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.

HORT 526
3(2+1)

Biotechnology of Horticultural Crops

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, soma-clonal 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*. Plenum Press.
- Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V. Academic Press.

HORT 527

Production Technology for Loose Flowers

3(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, 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, transportation and marketing, export potential, institutional support, Agri Export Zones.

Crops: Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, barleria, gomphrena, gaillardia, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies, 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 J.S. 2006. *Introductory Ornamental Horticulture*. Kalyani.

Bhattacharjee S.K. 2006. *Advances in Ornamental Horticulture*. vols. I-VI. Pointer Publ.

Bose T.K & Yadav LP. 1989. *Commercial Flowers*. Naya Prokash.

Bose T.K, Maiti R.G, Dhua R.S & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.

Chadha K.L & Chaudhury B.1992. *Ornamental Horticulture in India*. ICAR.

Chadha K.L. 1995. *Advances in Horticulture*. vol. XII. Malhotra Publ. House.

Lauria A & Ries V.H. 2001. *Floriculture – Fundamentals and Practices*. Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture*. Agrobios.

Randhawa G.S & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Sheela V.L. 2007. *Flowers in Trade*. New India Publ. Agency.

Valsalakumari P.K, Rajeevan P.K, Sudhadevi P.K & Geetha C.K. 2008. *Flowering Trees*. New India Publ. Agency.

HORT 528 3(2+1)

Production Technology of Underexploited Vegetable Crops

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.
UNIT III	Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu (chenopods).
UNIT IV	Elephant foot yam, lima bean, winged bean, vegetable pigeon pea and sword bean.
UNIT V	Sweet gourd, spine gourd, pointed gourd 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 K.L. 2001. *Minor Vegetables -Untapped Potential*. Kalyani.
 Indira P & Peter K.V. 1984. *Unexploited Tropical Vegetables*. Kerala Agricultural University, Kerala.
 Peter K.V. (Ed.). 2007-08. *Underutilized and Underexploited Horticultural Crops*. vols. I-IV. New India Publ. Agency.
 Rubatzky V.E & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall
 Srivastava U, Mahajan R.K, Gangopadhyay K.K, Singh M & Dhillon B.S. 2001. *Minimal Descriptors of Agri-Horticultural Crops*. Part-II: *Vegetable Crops*. NBPGR, New Delhi.

HORT 531 Landscaping and Ornamental Gardening 3(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, 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

Identification 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 shrubby borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Suggested Readings

Bose T.K, Maiti R.G, Dhua R.S & Das P.1999. *Floriculture and Landscaping*. Naya Prakash.

Lauria A & Yictor H.R. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Nambisan K.M.P.1992. *Design Elements of Landscape Gardening*. Oxford & IBH.

Randhawa G.S & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Sabina G.T & Peter K.Y. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency.

HORT 532

Post Harvest Technology for Fruit Crops

3(2+1)

Objective

To facilitate deeper understanding on principles and practices of post- harvest management of fruit crops.

Theory

UNIT I

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration.

UNIT II

Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.

UNIT III

Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage- ventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

UNIT IV

Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juice beverages, pickles, jam, jellies, sauces and ketchup, candies, preserve.

UNIT V

Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of shelf life extension in cut flower using chemicals, estimation of quality characteristics in stored fruits and vegetables, practices of preservation by salt, sugar, vinegar and chemical preservatives, cold chain management - visit to cold storage and CA storage units, visit to fruit and vegetable processing units, project preparation, evaluation of processed horticultural products.

Suggested Readings

Bhutani R.C. 2003. *Fruit and Vegetable Preservation*. Biotech Books.

Chadha K.L & Pareek O.P. (Eds.). 1996 *Advances in Horticulture*. Vol. IV. Malhotra Publ. House.

- Haid N.F & Salunkhe S.K. 1997. *Post Harvest Physiology and Handling of Fruits and Vegetables*. Grenada Publ.
- Mitra S.K. 1997. *Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits*. CABI.
- Ranganna S. 1997. *Hand Book of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill.
- Sudheer K.P & Indira V. 2007. *Post Harvest Technology of Horticultural Crops*. New India Publ. Agency.
- Willis R, Mc Glassen W.B, Graham D & Joyce D. 1998. *Post Harvest. An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals*. CABI.

HORT 533 Production Technology of Cool Season Vegetable Crops 3(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 Colecrops: cabbage, cauliflower, knol-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 T.K & Som M.G. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.
- Bose T.K, Som G & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.
- Bose T.K, Som M.G & Kabir J. (Eds.). 1993. *Vegetable Crops*. Naya Prokash.
- Bose T.K, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. vols. I-III. Naya Udyog.
- Chadha K.L & Kalloo G. (Eds.). 1993-94. *Advances in Horticulture* vols. V-X. Malhotra Publ. House.
- Chadha K.L. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.
- Chauhan D.V.S. (Ed.). 1986. *Vegetable Production in India*. Ram Prasad & Sons.
- Decoteau D.R. 2000. *Vegetable Crops*. Prentice Hall.
- Edmond J.B, Musser A.M & Andrews F.S. 1951. *Fundamentals of Horticulture*. Blakiston Co.
- Fageria M.S, Choudhary B.R & Dhaka R.S. 2000. *Vegetable Crops: Production*

Technology. vol. II. Kalyani.

Gopalakrishnan T.R. 2007. *Vegetable Crops*. New India Publ. Agency.

Hazra P & Som MG. (Eds.). 1999. *Technology for vegetable Production and Improvement*. Naya Prokash.

Rana M.K. 2008. *Olericulture in India*. Kalyani Publ.

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Rubatzky Y.E & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.

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Salunkhe D.K & Kadam S.S. (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.

Shanmugavelu K.G. 1989. *Production Technology of Vegetable Crops*. Oxford & IBH.

Singh D.K. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.

Singh S.P. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.

Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Thompson H.C & Kelly W.C. (Eds.). 1978. *Vegetable Crops*. Tata McGraw- Hill.

Ph.D Programme

HORT 611 Biotic And Abiotic Stress Management in Horticultural Crops 3(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 CO₂, 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 fluorescence, 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 M.N & Lewis C.F. 1982. *Breeding Plants for Less Favourable Environments*. Wiley Inter. Science.
- Gupta U.S. 1990. *Physiological Aspects of Dry Farming*.
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- Kramer P.J. 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 S.R. 2003. *Abiotic Stress and Crop Productivity*. Agrotech Publ. Academy.
- Mussell, H & Staples, R. 1979. *Stress Physiology in Crop Plants*. Wiley Inter. Science.
- Nickell, L.G. 1983. *Plant Growth Regulating Chemicals*. CRC.
- Peter, K.V. (Ed.). 2008. *Basics of Horticulture*. New India Publ. Agency.
- Turener, N.C & Kramer, P.J. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.

HORT 612

Biotechnology of Horticultural Crops

3(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, somoclonal variants 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.
- Panopoulos 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 Prakash.
- 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.

HORT 613

Advances in Breeding of Fruit Crops

3(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.

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 T.K, Mitra S.K & Sanyal D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*. 3rd Ed. Vols. I, II. Naya Udyog.

Chadha KL & Pareek O.P. (Eds.). 1996. *Advances in Horticulture*. Vol. I. Malhotra Publ. House.

Chadha K.L & Shikhamany S.D. 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 G.S. (Ed.). 1977. *Fruit Breeding in India*. Oxford & IBH.

Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

Singh S, Shivankar V.J, Srivastava A.K & Singh I.P. (Eds.). 2004. *Advances in Citriculture*. Jagminder Book Agency.

Stover R.H & Simmonds N.W. 1991. *Bananas*. Longman.

HORT 614 3(2+1)

Advances in Breeding of Vegetable Crops

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	Bhindi, 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

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 K.L, Ravindran P.N & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.

Chadha K.L. 2001. *Hand Book of Horticulture*. ICAR.

Dhillon B.S, Tyagi R.K, Saxena S & Randhawa G.J. 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publ. House.

Janick J.J. 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 K.V & Pradeep Kumar T. 2008. *Genetics and Breeding of Vegetables*. (Revised Ed.). ICAR.

Ram H.H. 2001. *Vegetable Breeding*. Kalyani.

HORT 615

Advances in Breeding of Flower Crops

3(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, lilioms, 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 J.S. 2006. *Introductory Ornamental Horticulture*. Kalyani.
Bhattacharjee S.K. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
Choudhary R.C.1993. *Introduction to Plant Breeding*. Oxford & IBH.
Singh B.D.1990. *Plant Breeding*. Kalyani.

HORT 621

Advances in Production of Fruit Crops

3(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.

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 T.K, Mitra S.K & Rathore D.S. (Eds.). 1988. *Temperate Fruits – Horticulture*. Allied Publ.
Bose T.K, Mitra S.K & Sanyal D. (Eds.). 2001. *Fruits -Tropical and Subtropical*. Naya Udyog.
Bose T.K, Mitra S.K, Farooqi A.A & Sadhu M.K. 1999. *Tropical Horticulture*. Vol. I. Naya Prokash.
Chadha K.L & Pareek O.P. (Eds.).1996. *Advances in Horticulture*. Vols. IIIIV. Malhotra Publishing House.
Chadha K.L. 2001. *Handbook of Horticulture*. ICAR.
Nakasone H.Y & Paull R.E. 1998. *Tropical Fruits*. CABI.
Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

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 T.K & Som N.G. 1986. *Vegetable Crops of India*. Naya Prakash.
- Bose T.K, Kabir J, Maity T.K, Parthasarathy V.A & Som M.G. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.
- Brewster J.L. 1994. *Onions and other Vegetable Alliums*. CABI. FFTC. *Improved Vegetable Production in Asia*. Book Series No. 36.
- Ghosh S.P, Ramanujam T, Jos J.S, Moorthy S.N & Nair R.G. 1988. *Tuber Crops*. Oxford & IBH.
- Gopalakrishnan T.R. 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 G.T, Palanisami M.S, Potty V.P, Padmaja G, Kabeerathuma S & Pallai SV. 1996. *Tropical Tuber Crops, Problems, Prospects and Future Strategies*. Oxford & IBH.
- Sin M.T & Onwueme I.C. 1978. *The Tropical Tuber Crops*. John Wiley & Sons.

Singh N.P, Bhardwaj A.K, Kumar A & Singh K.M. 2004. *Modern Technology on Vegetable Production*. International Book Distr. Co.
Singh P.K, Dasgupta S.K & Tripathi S.K. 2006. *Hybrid Vegetable Development*. International Book Distr. Co.

HORT 623

Protected Cultivation of Vegetable Crops

3(2+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/net house, hot beds, cold frames, effect of environmental factors, viz. temperature, light, CO₂ and humidity on growth of different vegetables, manipulation of CO₂, 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, CO₂ 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 & Som,V.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.

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; Micro irrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO₂ 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, lilies, 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 T.K, Maiti R.G, Dhua R.S & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.
- Chadha K.L & Choudhury B. 1992. *Ornamental Horticulture in India*. ICAR.
- George S & Peter K.V. 2008. *Plants in a Garden*. New India Publ. Agency.
- Lauria A & Victor H.R. 2001. *Floriculture – Fundamentals and Practices*. Agrobios.
- Randhawa G.S & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
- Reddy S, Janakiram B, Balaji T, Kulkarni. S & Misra R.L. 2007. *Hightech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.

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, lilliums, 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 S.K. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
Bose T.K, Maiti R.G, Dhua R.S & Das P. 1999. *Floriculture and Landscaping*. Naya Prakash.
Reddy S, Janakiram B, Balaji T, Kulkarni S, & Misra R.L. 2007. *Hightech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.

List of Journals & Magazines

FRUIT SCIENCE

- ☐ 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

VEGETABLE SCIENCE

- ☐ 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

FLORICULTURE AND LANDSCAPE ARCHITECTURE

- ☐ Acta Horticulture
- ☐ Floriculture Today
- ☐ 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
- ☐ Journal of Landscape architecture
- ☐ Journal of Ornamental Horticulture
- ☐ Scientia Horticulture
- ☐ South Indian Horticulture

PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

- ☐ 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

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/>
 Asian Vegetable Research and Development Center (AVRDC) <http://www.avrdc.org.tw/>
 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/>
 Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram <http://www.ctcri.org/>
 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 Scientific and Industrial Research, India <http://dsir.nic.in/> FAO
<http://www.fao.org/>
 Global Agribusiness Information Network: <http://www.fintrac.com/gain/>
 Greenhouse Vegetable Information: <http://www.ghvi.co.nz/>
 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/>
 Indo-American Hybrid Seeds www.indamseeds.com
 Institute of Vegetable and Ornamental Crops <http://www.igzev.de/>
 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),
<http://www.manage.gov.in/>
 National Research Centre for Cashew (NRCC), <http://kar.nic.in/cashew/> India
 National Research Centre for Mushroom (NRCM), India <http://www.nrcmushroom.com/>
 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>
 Pineapple News <http://agrss.sherman.hawaii.edu/pineapple/pineappl.htm>
 Pomology Resources Center <http://www.bsi.fr/pomologie/english/> /pomology:
 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 Agribusiness on-line <http://www.agro-lanka.org/>
 Sustainable Apple Production: <http://orchard.uvm.edu/>
 Tea Board, India <http://tea.nic.in/>
 The Horticultural Taxonomy Group <http://www.hortax.org.uk/>
 The International Society of Citriculture: http://www.lal.ufl.edu/isc_citrus_ho_mepage.htm
 The Internet Garden <http://www.internetgarden.co.uk/>
 The Rose Resource <http://rose.org/>
 The USDA Agricultural Research Service <http://www.ars.usda.gov/>
 University of Florida, Dept. of Environmental Horticulture <http://hort.ifas.ufl.edu/>
 University of California, Fruit&Nut Research <http://fruitsandnuts.ucdavis.edu/>
 US Environmental Protection Agency <http://www.epa.gov/>
 USDA <http://www.usda.gov/>

PLANT BREEDING AND GENETICS

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	PBG 511*	PRINCIPLES OF GENETICS AND CELL BIOLOGY	3 (2+1)
2.	PBG 512*	PRINCIPLES OF PLANT BREEDING	3 (2+1)
3.	PBG 513	MOLECULAR GENETICS	3(3+0)
II- Semester			
4.	PBG 521	PLANT GENETIC RESOURCES AND SEED TECHNOLOGY	3 (2+1)
5.	PBG 522*	PRINCIPLES OF QUANTITATIVE GENETICS	3 (2+1)
6.	PBG 523*	BIOTECHNOLOGY FOR CROP IMPROVEMENT	3 (2+1)
7.	PBG 524	PRINCIPLES OF CYTOGENETICS	3 (2+1)
8.	PBG 525	POPULATION GENETICS	3 (2+1)
9.	PBG 526	BREEDING CEREALS, MILLETS AND FORAGES	3 (2+1)
10.	PBG 527	BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS	3 (2+1)
11.	PBG 528	BREEDING FOR QUALITY TRAITS	3 (2+1)
12.	PBG 529	GENE REGULATION AND EXPRESSION	3(3+0)
III- Semester			
13.	PBG 531	MUTAGENESIS AND MUTATION BREEDING	3 (2+1)
14.	PBG 532	HETEROSIS BREEDING	3 (2+1)
15.	PBG 533	BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE	3 (2+1)
16.	PBG 534	GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE	3 (2+1)
17.	PBG 535	DATA BASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR	3 (2+1)
18.	PBG 536	MAINTENANCE BREEDING AND CONCEPTS OF VARIETY RELEASE AND SEED PRODUCTION	3 (2+1)
IV- Semester			
19.	PBG 541	SEMINAR	1
20.	PBG 542	COMPREHENSIVE	2
21.	PBG 543	RESEARCH	15
Ph.D.			
I- Semester			
1.	PBG 611	CROP-EVOLUTION	3(3+0)
2.	PBG 612*	ADVANCED GENETICS	3(3+0)
3.	PBG 613	PLANT GENETIC RESOURCES AND PRE-BREEDING	3(3+0)
4.	PBG 614	ADVANCES BIOMETRICAL AND QUANTITATIVE GENETICS	3(2+1)
5.	PBG 615	ADVANCED PLANT BREEDING SYSTEMS	3(3+0)
6.	PBG 616	MICROBIAL GENETICS	3(2+1)
II- Semester			
7.	PBG 621*	GENETIC ENGINEERING	3(2+1)
8.	PBG 622	GENOMICS IN PLANT IMPROVEMENT	3(2+1)
9.	PBG 623	MOLECULAR AND CHROMOSOMAL MANIPULATIONS FOR CROP BREEDING	3(2+1)
10.	PBG 624	BREEDING DESIGNER CROPS	3(2+1)
11.	PBG 625	ADVANCES IN BREEDING OF MAJOR FIELD CROPS	3(3+0)
12.	PBG 626	<i>IN SITU</i> AND <i>EX SITU</i> CONSERVATION OF GERMPLASM	3(2+1)
III- and onward semesters			
13	PBG 641	SEMINAR	2
14.	PBG 642	PRELIMINARY	4
15.	PBG 643	RESEARCH	40

* Core courses

PLANT BREEDING AND GENETICS

M.Sc. (Ag) Programme

PBG 511

Principles of Genetics and Cell Biology

3(2+1)

Objective

This course is aimed at understanding the basic concepts of genetics, and cell biology helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Theory

Principles of genetics:

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, Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes. Crossing over-mechanisms and theories of crossing over-recombination models, cytological basis. Somatic cell genetics, Extra chromosomal inheritance

UNIT III

Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioral genetics.

Cell Biology:

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, plastids-chloro/chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

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.

UNIT III

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition.

Practical

Numericals related to Mendel's laws, gene interaction, linkage and construction of genetic maps. Polygenic inheritance. 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; Principles of microscopy: phase contrast, autoradiography and electron microscopy. Differential centrifugation for isolating macroscopic components. Preparation and use of different killing and fixation reagents used in cytological studies. Preparation of important stains like aceto carmalum, aceto orcin and fuelsen stain. Exercises related cell division- mitosis and meiosis.

Suggested Readings

B.D.Singh. 2005. Genetics. Kalyani Publishers, Ludhiana.

Gardner EJ, Simmons, M J and Snustad DP. 1991. Principles of Genetics. John Wiley & Sons

Karp G. 2008. Cell and Molecular Biology: Concepts and Experiments. John Wiley and Sons.

Klug WS & Cummings MR. 2003. Concepts of Genetics. Peterson Edu.

Lewin B. 2008. Genes IX. Jones & Bartlett Publ.

P.K.Gupta. 2006. Cell Biology, Rastogi Publications.

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 on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

PBG 512

Principles of Plant Breeding

3(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

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 apomixes, 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.

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. Jodhpur
- 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.
- Dana, Sukumar. 2001. *Plant Breeding*. Naya Udyog, Colcutta. 700 006
- Kucku, Kobabe and Wenzel (1995). *Fundamentals of Plant Breeding*. Narosa Publishing House, New Delhi
- 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.
- Stoskopf, N C, Tomes, D T and Christie. 1993. *Plant breeding: theory and Practice*. Scientific Publishers(India) Jodhpur.

PBG 513

Molecular Genetics

3(3+0)

Objective

To impart knowledge in theory of structure and function of genetic material and major macromolecules of the cell.

Theory

UNIT I

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, Genetic code, DNA transcription and its regulation – Transcription factors and their role; regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors.

UNIT II

Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; Gene amplification and its significance; Proteomics and protein-protein interaction.

UNIT III

Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.

UNIT IV

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and

suppression; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing.

UNIT V

Genomics and proteomics; Functional and pharmacogenomics; Metagenomics. Signal transduction; Genes in development; Cancer and cell aging

UNIT VI

Methods of studying polymorphism at biochemical and DNA level;

Suggested Readings

Bruce A. 2004. *Essential Cell Biology*.

Friefelder, D. 1990. Molecular genetics. Narosa Publishing house, New Delhi.

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.

Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

Schleif R. 1986. *Genetics and Molecular Biology*. Addison-Wesley Publ. Co. WH Freeman & Co.

WH Freeman. Nelson DL & Cox MM. 2005. *Lehninger's Principles of Biochemistry*.

Winter, P C., Hickey, G I., and Fletcher, H L. 1999. Instant Notes in Genetics. Viva Book Pvt. Ltd. New Delhi.

PBG 521

Plant Genetic Resources & Seed Technology

3(2+1)

Theory:

Genetic resources in historical perspectives, gene pool, centres of origin and diversity. Types of genetic resources and their survey- objectives, limitations, priorities and techniques. Germplasm introduction and exchange. Principles of *in vitro* and cryopreservation. Germplasm conservation *in-situ*, *ex situ* and on farm, short, medium, long term conservation strategies for orthodox and non-orthodox seed, vegetatively propagated crops. Rajasthan of plant genetic resources, PGR data base management, descriptors. Regional, national and international mechanism for PGR management. Plant genetic resources for food and agriculture. PGR access and benefit sharing; IPR, PBR, UPOV & CBD issues; farmers' rights & privilege.

History of seed industry and role of various seed organizations. Seeds act and seed rules and law enforcement. Seed control order. New seed act seed policy. Variety: definition, types, development, release system and notification. Objectives and principles of seed production. Factors affecting seed production, variety maintenance, nucleus and breeder seed production in different crop groups. Production of certified and foundation seed in different crop plants *viz*; cereals, oilseeds, pulses, fibre and forage crops. Concept, purpose and phases of seed certification, seed certification agency. Variety eligibility, class and sources of seed, field inspection and minimum seed and field certification standards. DUS test and VCU. Variety identification through biochemical procedures.

Practical:

Seed testing methods and seed dormancy. Seed production planning in different crops with special reference to land and isolation requirements. Roguing, harvesting and threshing. Character of important varieties and its maintenance. Field inspection at different crop growth stages off types, pollen shedders, seed borne diseases. Visit to seed production plots. Visit to gene bank.

Suggested Readings:

Dhirendra Khare and Mohan S. Bhale, 2000. Seed Technology. Scientific Publishers, P.O. Box 91, Jodhpur.

F.L. Brian and M. Jackson, 1986. Plant Genetics Resources- An introduction to their conservation and use. Edward Arnold, London.

Gautam, P.L., Dabas, B.S., Srivastava, V and Duhoon, D.S. (Eds.), 1988. Plant Germplasm Collecting Principles and Procedures. NBPGR Publication, NBPGR, New Delhi.

J.H.W. Holden and J.T. Williams, 1984. Crop Genetic Resources, Conservation and Evaluation. Oxford Books and Stationary Co., Delhi.

N. Ghosh and Subirsan, 1999. Seed Science and Technology. Kalyani Publishers, Ludhiana.

Paroda, R.S., Arora, R.K. and Chandel, K.P.S. (Eds.), 1988. Plant Genetic Resources. Indian Perspective. NBPGR, New Delhi.

R.L. Agrawal, 1996. Seed Technology. IBH Publishing CO., New Delhi.

Tomar, H.S., 2003. Seed Technology. Aman Publishing House, Meerut (U.P.)

PBG 522

Principles of Quantitative Genetics

3(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

Population - Mendelian population – Random mating population -Frequencies of genes and genotypes-Causes of change: Hardy- Weinberg equilibrium.

UNIT II

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 III

Principles of Analysis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance.

UNIT IV

Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D^2 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 V

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.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis -Metroglyph analysis - D^2 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 covariance 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.
 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.

PBG 523
3(2+1)

Biotechnology for Crop Improvement

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, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

UNIT III

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR-based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction

and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs). 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 IV

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Marker-assisted backcross breeding for rapid introgression, Generation of EDVs. Gene pyramiding.

UNIT V

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, 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.

UNIT VI

Biotechnology applications in male sterility/hybrid breeding, molecular farming. Gene silencing.

UNIT VII

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

Bioinformatics & Bioinformatics tools.

UNIT IX

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; 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. 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

Chawala H.S. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.

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 to Recombinant 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.

Objective

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

Theory**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

Variation in chromosome structure: Evolutionary significance -Introduction to techniques for karyotyping; Chromosome banding and painting -in situ hybridization and various applications.

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; Apomixis - Evolutionary and genetic problems in crops with apomixes.

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- In vitro techniques to overcome the fertilization barriers in crops; 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, 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 the course of mitosis in onion. Studies on the course of meiosis - Using micrometers and studying the pollen grain size in various crops - Pollen germination and in vitro; Demonstration of polyploidy.

Suggested Readings

B.D.Singh. 2005. Genetics. Kalyani Publishers

Becker K & Hardin. 2004. The World of Cell. 5th Ed. Pearson Edu.

CarrollM.1989.Organelles.The Guilford Press.

CharlesB.1993. Discussions in Cytogenetics.Prentice Hall.

Darlington CD & La Cour LF. 1969. The Handling of Chromosomes.

- Gray P. 1954. The Microtome's Formulary 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 and Practice.
- Sumner AT. 1982. Chromosome Banding. Unwin Hyman Publ.
- Swanson CP. 1960. Cytology and Cytogenetics. Macmillan & Co.

PBG 525

Population Genetics

3(2+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 - 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; Homeostasis- Adaptive organization of gene pools, Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage- Survival of recessive and deleterious alleles in populations.

Practical

Genetic exercise on probability; Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average effect 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 - A Practical 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.

PBG 526

Breeding Cereals, Millets and Forages

3(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.

UNIT II

Wheat: 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, 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 objectives- yield, quality characters, biotic and abiotic stress resistance *etc.*

UNIT IV

Millets (sorghum, pearl millet and minor millets) 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. Practical learning on the cultivation of fodder crop species on sewage water; analysing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Visit to animal feed producing factories, learning the practice of value addition; visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

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.
- Crop Breeding in India*. International Book Distributing Co.
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- 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.
- Slater GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.
- Walden DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.

PBG 527
3(2+1)

Breeding Legumes, Oilseeds and Fibre Crops

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 objectives- yield, 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.

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

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; 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 and Marketing*. 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.

PBG 529

Gene Regulation and Expression

3(3+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*. CPL Scientific Publ.
Brooker RJ. 2004. *Genetics Analysis and Principles*. Addison-Wesley Longman.
Watson JD. 2004. *Molecular Biology of the Gene*. Pearson Edu.

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, α and β particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations (γ , 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 and modifying 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 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement,etc) in different crops- Procedures for micro-mutations 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; 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 Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energy Agency, Vienna, Italy.
 Singh BD. 2007. *Genetics*. Kalyani.
 Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

PBG 532

Heterosis Breeding

3(2+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 self-incompatibility 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 Hui Lin. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.

De Jong 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.

Rai, B. Heterosis breeding. Agro-biological publications, New Delhi.

PBG 533

Breeding for Biotic and Abiotic Stress Resistance

3(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.

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, chitinases 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 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.
 D.P.Singh.

PBG 534

Germplasm Collection, Exchange and Quarantine

3(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

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.

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, egPBGlant, 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 of Achievements*. 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 Project Management.
- Sivarajan VV. 1991. *Introduction of Principles of Plant Taxonomy*. Science Publ.
- Stace CA. *Plant Taxonomy and Biosystematics 2nd Ed.* Cambridge Univ. Press.
- Takhrajan A. 1997. *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.
- Wiersema JH. 1999. *World Economic Plants: A Standard Reference*. Blanca Leon.

PBG 535 Data Base Management, Evaluation and Utilization of PGR 3(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 agro-biodiversity and agricultural development crop diversification-participatory 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, New Delhi.

Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.

PBG 536 Maintenance Breeding and Concepts of Variety Release and Seed

Production

3(2+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, pearl millet, 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.

Ph. D Programme

PBG 611

Crop Evolution

3(3+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.

PBG 612

Advanced Genetics

3(3+0)

Theory:

Secondary structures of DNA (A,B,C,Z and P- DNA). Denaturation and renaturation of DNA- supercoils, cruciforms and triple stranded structures. Secondary and tertiary structures of RNA. Ribozyme and deoxyribozymes. Physico chemical organization of chromatin and nucleosome, concept. Telomerases . DNA repair and recombination. Gene duplication, amplification and pseudogenes; Arrangements of genes in eucaryotes. Mobile genetic elements in pro and eucaryotes and their significance. Organization of mitochondrial and chloroplast genomes, Plasmid biology. Aims and principles of gene transfer, vectors, restriction enzymes, distinguishing transferred genes from endogenous genes.. *In vitro* synthesis of recombinant DNA and gene cloning techniques, developmnt of transgenic plants and potential hazards of gene cloning. Molecular Markers, types and significance. Genome projects, genomics, proteomics

References:

- Lewin, B. 2000 Genes VII. Oxford Univ. Press, New York.
Brown, T.A. 1998. Genomes. Johm Wily and Sons (East Asia). Singapore.
Alberts, B. et al 1994. Molecular Biology of the cell 3rd. Garland Publishing, New York.
Singh B.D. 1990. Fundamental of genetics. Kalyani Publishers, Ludhiyana.
Karp, G. 1999. Cell and Molecular Biology. Johm Wily and Sons (East Asia). Singapore.
Freifelder, D. 1995. Molecular Biology. Narosa Publishing House, New Delhi.
Birge EA 1988. Bacterial and Bacteriophage Genetics, 2nd Edition. Springer Verlag.

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 enhancement/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 Collecting: 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 & Hazeekamp 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.

PBG 614

Advanced Biometrical and Quantitative Genetics

3(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 genotypes.

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 - Trialallel 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.
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.

PBG 615

Advances in Plant Breeding Systems

3(3+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- incompatibility and sterility – Types of self incompatibility: 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 in exploiting 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- incompatibility 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.

PBG 616

Microbial Genetics

3(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-phase 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 N₂fixing 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. 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 Biology of the Gene*. Pearson Edu. Yadav AS, Vasudeva M, Kharab P & Vashishat RK. 2002. *Practical Manual on Microbial and Molecular Genetics*. Dept. of Genetics, CCS HAU Hisar.

PBG 621

Genetic Engineering

3(2+1)

Theory:

Perspectives and application of genetic engineering. Methods of recombinant technology. Isolation, sequencing, cloning of prokaryotic and eucaryotic genes. Basic differences in the expression of pro and eucaryotic gene expression. Analytical techniques in genetic engineering. Immunogenetics. Nature and function of restriction enzymes. Plasmid structure, function and biology. Construction of plasmid vectors. Biology of bacteriophage lambda and M13. Specialised vectors. Gene cloning in plasmids. *Agrobacterium* plasmids (Ti and Ri). Methods of direct gene transfer-electroporation, microinjection, use of particle gun. Construction of genomic libraries. PCR and its use. Genetic manipulation, construction of transgenic in pro and eucaryotes..

Practicals

Isolation of DNA. DNA melting, annealing and plotting of cot values, isolation of plasmid DNA, Protoplast fusion, Triparental mating. Visit to the Biotechnology laboratories of national repute.

Suggested Readings

Old, R.W. and Primrose, S.B. 2001. Principles of Genetic manipulation: An Introduction to Genetic Engineering, 5th Edition. Blackwell Scientific Limited, USA. Singh, B.D. 1999. Biotechnology. Kalyani Publishers, Ludhiyana.

Liu Ben Hui. 1998. Statistical Genomics : Linkages, Mapping and QTL Analysis. CRC Press LLC, Florida, USA.
 Chawala, H.S. 2002. Introduction to plant biotechnology, 2nd edition. Oxford& IBH, New Delhi
 Freifelder, D. 2000. Microbial Genetics. Narosa Publishing House, New Delhi.
 Birge EA 1988. Bacterial and Bacteriophage Genetics, 2nd Edition. Springer Verlag.

PBG 622

Genomics in Plant Breeding

3(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 sequences using 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 and Future*. 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*. Cold Spring 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 to Function*. Viva Books.
 Rampal JB. 2001. *DNA Arrays: Methods and Protocols*. Humana Press.

PBG 623 Molecular and Chromosomal Manipulations for Crop Breeding 3(3+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; Interchange-genetic 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; Monosomics methods of production, breeding behavior 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.

PBG 624

Breeding Designer Crops

3(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.

PBG 625

Advances Inbreeding of Major Field Crops

3(3+0)

Objective

To provide insight into recent advances in improvement of cereals, millets and non cereal crops 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, Pearl millet, Sorghum, Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc.

UNIT II

Breeding objectives in rice, wheat, maize, pearl millet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

UNIT III

Breeding for value addition and resistance to abiotic and biotic stresses.

UNIT IV

Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics.

UNIT V

National and International accomplishments in genetic improvement of major field crops and their seed production.

Suggested Readings

- 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 & Harinarianan H. (Eds.). 1999. *Pearl Millet Breeding*. Oxford & IBH.
Khairwal I, Ram C & Chhabra AK. 1990. *Pearl Millet Seed Production and Technology*. Manohar Publ.
Nagarajan S, Singh G & Tyagi BS. 1998. *Wheat Research Needs Beyond 2000 AD*. Narosa.
Nanda JS. 2000. *Rice Breeding and Genetics - Research Priorities and Challenges*. Oxford & IBH.
Rao VS, Singh G & Misra SC. 2004. *Wheat: Technologies for Warmer Areas*. Annamaya Publ.
Reynolds MP, Rajaram S, McNab A. 1996. *Increasing Yield Potential in Wheat: Breaking the Barriers*. Proc. Workshop held in Ciudad, Obregon, Sonora, Mexico.
Seth BL, Sikka SM, Dastur RH, Maheshwari P, Rangaswamy NS & Joshi AB. 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.

PBG 626

In Situ and Ex Situ Conservation of Germplasm

3(2+1)

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* conserved genetic 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, maintenance of *in vitro* culture under different conditions, *in vitro* bank maintenance for temperate 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, desiccation, 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 aheads.

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 for assessing 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 Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks*. FAO / IBPGR Pl. Genet. Resources News 41-3-18.

Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, Cambridge.

Simmonds, N.W. 1979. *Principles of Crop Improvement* Longman.

Westwood MN. 1986. *Operation Manual for National Clonal Germplasm Repository Processed Report*. USDA-ARS and Oregon State Univ. Oregon, USA. Withers LA. 1980. *Tissue Culture Storage for Genetic Conservation*. IBPGR Tech. Rep. IBPGR, Rome, Italy.

List of Journals

- Australian Journal of Biological Sciences, Australia
- Australian Journal of Agricultural Research, Australia
- Biometrics, UK
- BioTechniques
- Cereal Research Communication, Hungary
- Cotton Research and Development, Hisar, India
- Crop Improvement, Ludhiana
- Crop Science, USA
- Current Science, Bangalore
- Critical Reviews in Plant Sciences
- Czech Journal of Plant Breeding Genetics, Prague,
- Electronic Journal of Biotechnology
- Euphytica, The Netherlands
- FABIS Newsletter
- Forage Research, Hisar, India
- Genetics, USA
- Genome, Canada
- Genetic resources and crop evolution, Netherlands
- Haryana Agricultural University Journal of Research, Hisar, India
- Heredity
- Hilgardia, Sweden,
- Indian Journal of Agricultural Research, New Delhi
- Indian Journal of Genetics and Plant Breeding, New Delhi
- Indian Journal of Plant Genetic Resources, New Delhi
- International Chickpea Newsletter, ICRISAT
- International Rice Research Notes, IRRI, Philippines
- Journal of Agricultural Research, U.K.
- Journal of Biochemistry and Biotechnology, New Delhi
- Journal of Genetics and Breeding, Italy
- Journal of Heredity
- Journal of Pulses Research, Kanpur
- Legume Research, Karnal
- MILWAI Newsletter
- Madras Agricultural Journal, Coimbatore, India
- Molecular Breeding, USA
- Mutation Research
- National Journal of Plant Sciences, Hisar, India
- Nucleic Acids Research, USA
- Oryza, Cuttack, India
- PGR Newsletter, Syria
- Plant Breeding, Germany

- Plant Molecular Biology, The Netherlands
- Rachis, Syria (Presently it is not published)
- Sorghum and Millet Newsletter, ICRISAT
- Theoretical and Applied Genetics, Germany
- Wheat Research, Japan

e-Resources

Name of the Journal	URL
Agronomy Research	http://www.eau.ee/~agronomy/
Asian Journal of Plant Sciences	http://ansijournals.com/3/c4p.php?id=1&theme=3&jid=ajps
Breeding Science	http://www.jstage.jst.go.jp/browse/jsbbs
Current Science	http://www.ias.ac.in/currsci/index.html
International Journal of Botany	http://ansijournals.com/3/c4p.php?id=1&theme=3&jid=ijb
International Journal of Sociology of Agriculture and Food	http://www.csafe.org.nz/ij saf/
Japan Agricultural Research Quarterly	http://ss.jircas.affrc.go.jp/english/publication/jarq/index.htm
Japanese Journal of Crop Sc.	http://www.jstage.jst.go.jp/browse/jcs
Journal of Agronomy	http://ansijournals.com/3/c4p.php?id=1&theme=3&jid=ja
Journal of Biosciences	http://www.ias.ac.in/jbiosci/index.html
Journal of Cotton Science	http://www.cotton.org/journal/
Journal of Genetics	http://www.ias.ac.in/jgenet/index.html
Plant Biotechnology	http://www.jstage.jst.go.jp/browse/plantbiotechnology
Plant Production Science	http://www.jstage.jst.go.jp/browse/pps
Scientia Agraria	http://calvados.c3sl.ufpr.br/ojs2/index.php/agraria
Tropicultura	http://www.bib.fsagx.ac.be/tropicultura/
Turkish Journal of Agriculture and Forestry Sciences	http://journals.tubitak.gov.tr/agriculture/index.php

ENTOMOLOGY

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	ENT 511*	INSECT MORPHOLOGY	3(2+1)
2.	ENT 512	INSECT ECOLOGY	3(2+1)
3	ENT 513*	PRINCIPLES OF INTEGRATED PEST MANAGEMENT	3(2+1)
II-Semester			
4.	ENT 521*	CLASSIFICATION OF INSECTS	3(2+1)
5.	ENT 522*	INSECT PHYSIOLOGY AND NUTRITION	3(2+1)
6.	ENT 523	TOXICOLOGY OF INSECTICIDES	3(2+1)
7.	ENT 524	PESTS OF FIELD CROPS	3(2+1)
8	ENT 525	SOIL ARTHROPODS AND THEIR MANAGEMENT	3(2+1)
III-Semester			
9	ENT 531	PESTS OF HORTICULTURAL AND PLANTATION CROPS	3(2+1)
10.	ENT 532	STORAGE ENTOMOLOGY	3(2+1)
11.	ENT 533	BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS	3(2+1)
12.	ENT 534	COMMERCIAL ENTOMOLOGY	3(2+1)
13.	ENT 535	PLANT RESISTANCE TO INSECTS	3(2+1)
14	ENT 536	GENERAL ACAROLOGY	3(2+1)
15	ENT 537	VERTEBRATE PEST MANAGEMENT	3(2+1)
IV-Semester			
16.	ENT 541	SEMINAR	1
17.	ENT 542	COMPREHENSIVE	2
18.	ENT 543	RESEARCH	15
Ph.D.			
I-Semester			
1.	ENT 611*	MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH	3(3+0)
2	ENT 612	ADVANCED INSECT PHYSIOLOGY	3(3+0)
II-Semester			
4.	ENT 621*	ADVANCED INTEGRATED PEST MANAGEMENT	3(3+0)
5	ENT 622	RECENT TRENDS IN BIOLOGICAL CONTROL	3(2+1)
6	ENT 623	PLANT BIOSECURITY AND BIOSAFETY	3(3+0)
7	ENT 624	ADVANCED INSECTICIDE TOXICOLOGY	3(2+1)
III and onward Semesters			
8	ENT 641	SEMINAR	2
9	ENT 642	PRELIMINARY	4
10	ENT 643	RESEARCH	40

*Core courses

List of minor courses:

M.Sc(Ag)			
I-Semester			
1.	STAT 511	STATISTICAL METHODS FOR APPLIED SCIENCES	3(2+1)
2.	PPATH 513	PRINCIPLES OF PLANT PATHOLOGY	3(2+1)
II-Semester			
3.	BIOCHEM 521	BASIC BIOCHEMISTRY	3(2+1)
III-Semester			

4.	PPATH 532	PRINCIPLES OF PLANT DISEASE MANAGEMENT	3(2+1)
5	PPATH 533	DISEASE OF FIELD AND MEDICINAL PLANTS	3(2+1)
Ph.D			
I-Semester			
1.	BIOCHEM 532	BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESS	3(2+1)
2.	PPATH 512	DETECTION AND DIAGNOSIS OF PLANT DISEASES	3(0+3)
II-Semester			
3.	NEMAT 521	NEMATODE DISEASES OF CROPS	3(2+1)
4	PPATH 523	DISEASES OF VEGETABLES AND SPICE CROPS	3(2+1)

ENTOMOLOGY

M.Sc.(Ag) Programme

ENT 511

Insect Morphology

3(2+1)

Objective

To acquaint the students with external morphology of the insect's body i.e., head, thorax and abdomen, their appendages and functions. To study the anatomy of different systems.

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, structure 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 (mechanical, photo- and chemo- receptors).

UNIT V

Structure of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands.

Practical

Dissection of cockroach/ grass hopper to study comparative anatomical details of different systems. 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.
- Snodgrass RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.

ENT 512

Insect Ecology

3(2+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 indices. Train students in sampling methodology, calculation of diversity indices, 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. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche- ecological 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 ork.

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.

**ENT 513
3(2+1)**

Principles of Integrated Pest Management

Objective

To familiarize the students with principles of insect pest management, including concept

and philosophy of IPM. Train students in computation of ETL, implementing IPM programmes.

Theory

UNIT I

History and origin, definition and evolution of various related terminologies.

UNIT II

Concept of IPM; Economic decision levels of insect pest population.

UNIT III

Insect dominance, increase in agriculture pest problem, pest outbreak and factors affecting it; Categories of pest.

UNIT IV

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods, host plant resistance, biological control, semiochemicals, botanicals and chemical control, insecticide resistance management; sampling, survey, surveillance and forecasting. Controversies, criticism and constraints in IPM. Case studies of successful IPM programmes. Pest control appliances and their maintenance.

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. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Use of pest control appliances and their maintenance.

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*. 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 anagement*. Elite Publ., New Delhi.
- Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest anagement*. 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.

ENT 521

Classification of Insects

3(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

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 II

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 III

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 Panorpid 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

Blackwelder RE. 1967. *Taxonomy - A Text and Reference Book*. John Wiley & Sons, New York.

Kapoor VC. 1983. *Theory and Practice in Animal Taxonomy*. Oxford & IBH, New Delhi.

Mayr E. 1971. *Principles of Systematic Zoology*. Tata McGraw-Hill, 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.

ENT 522

Insect Physiology and Nutrition

3(2+1)

Objective

To impart knowledge to the students on the elementary physiology, nutritional physiology and their application in entomology.

Theory

UNIT I

Scope and importance of insect physiology and nutrition.

UNIT II

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 micro- organisms and their role in physiology; artificial diets.

Practical

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.

ENT 523

Toxicology of Insecticides

3(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 organo- chlorines, 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; quality control of pesticide formulations; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides; visit to toxicology laboratories. Good laboratory practices.

Suggested Readings

Chattopadhyay SB. 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.

ENT 524

Pests of Field Crops

3(2+1)

Objective

To familiarize the students about nature of damage and seasonal incidence of insect pests that cause 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 and mite pests and vectors.

UNIT I

Insect pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs etc.).

UNIT II

Insect pests of pulses, tobacco, oilseeds and their management.

UNIT III

Insect 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.

ENT 525 Soil Arthropods and Their Management

3(2+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, inter- relationship among arthropods and other soil invertebrates and soil microorganisms. Role of soil mites in humus formation. Vertical and horizontal distribution of soil mites. 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.

ENT 531 Pests of Horticultural and Plantation Crops 3(2+1)

Objective

To impart knowledge on major pests of horticultural and plantation crops regarding the 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 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 crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine 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 non- insect pests.

Suggested Readings

Atwal AS & Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management*. 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.

ENT 532

Storage Entomology

3(2+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 vis- à-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).

Suggesting Readings

Bhargava, M.C. and Kumawat, K.C. 2010. Pests of Stored Grains and Their management, New India Publishing Co. New Delhi

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.

ENT 533

Biological Control of Crop Pests and Weeds 3(2+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.

ENT 534

Commercial Entomology

3(2+1)

Objective

To familiarize the students with entrepreneurial opportunities in entomology, provide information on productive insects and their products, as well as insect pests of public health and veterinary importance and their management.

Theory

UNIT I

Bee keeping- General colony management during different seasons. Seasonal management. Managing colonies for honey production and pollination. Artificial queen

rearing. Pests and diseases of honey bees. Bee poisoning. Production and marketing of quality honey and value added honey products. Establishment and maintenance of apiaries.

UNIT II

Study of different species of silkworms, characteristic features, moriculture, silk and its uses, pests and diseases of silkworms, rearing and management of silkworms. Lac insect-natural enemies and their management.

UNIT III

Economic and public health importance of insect pests in human habitation and habitats, biology, damage and control of mosquitoes, houseflies, bed bugs, ants, termites, cockroaches, flies, silverfish, head and body lice, carpet beetles, cloth moths, crickets, wasps, house dust mites, insect 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

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 assessing pest status in poultries. Evaluation of commercially available domestic insect pest control products through bioassays. Identification of honey bee species, bee castes and special adaptations, identification and handling of bee-keeping equipments. Handling of honey bees-hive and frame inspection. Honey extraction and processing methods of hive products extraction. Preparation of bee-keeping projects for funding. Visit to bee nursery and commercial apiaries. Silkworm rearing and management. Lac host and crop. management technology and processing of lac. Products and bye-products of lac.

Suggested Readings

- Aruga H. 1994. *Principles of Sericulture*. Oxford & IBH, New Delhi.
Atwal AS. 2006. *The World of the Honey Bee*. Kalyani Publ., New Delhi.
Ganga G. 2003. *Comprehensive Sericulture*. Vol. II. *Silkworm Rearing and Silk Reeling*. Oxford & IBH, New Delhi.
Partiban S & David BV. 2007. *Management of Household Pests and PublicHealth Pests*. Namratha Publ., Chennai.
Singh S. 1975. *Beekeeping in India*. ICAR, New Delhi.

ENT 535

Plant Resistance to Insects

3(2+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.

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.

ENT 536 3(2+1)

General Acarology

Objective

To acquaint 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, ND.
- Gerson U & 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.
- 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, N. Delhi.
- Walter DE & Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviour*. CABI, London.

ENT 537

Vertebrate Pest Management

3(2+1)

Objective

To impart knowledge on vertebrate pests like birds, rodents, mammals etc. of different crops, their biology, damage they cause and management strategies.

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.

Prakash I & Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.

Prakash I & Ghosh RP. 1987. *Management of Rodent Pests*. ICAR, New Delhi.

Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay.

Ph.D Programme

ENT 611 Molecular Approaches in Entomological Research 3(2+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 analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, *Bt* and entomopathogenic fungi.

UNIT III

Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Bt toxin, CPTI; trypsin inhibitors, lectins and proteases, neuropeptides. Transgenic plants for pest resistance and diseases.

UNIT IV

Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.

UNIT V

DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

Suggested Readings

Bhattacharya TK, Kumar P & Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publ., New Delhi.

Hagedorn 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.

ENT 6 12

Advanced Insect Physiology 3(3+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.

ENT 621

Advanced Integrated Pest Management

3(3+0)

Objective

To acquaint the students with recent concepts of integrated pest management. Surveillance 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' real-time situations (IPM modules of important crops).

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 Pest Management*. 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.

Pedigo RL. 1996. *Entomology and Pest Management*. Prentice Hall, New Delhi.

Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

ENT 622

Recent Trends in Biological Control 3(2+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.
- Huffaker CB & Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

ENT 623

Plant Biosecurity and Biosafety

3(3+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), 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_CD_S_EPR_2006.

Grotto Andrew J & Jonathan B Tucker. 2006. *Biosecurity: A Comprehensive Action Plan*.

http://www.americanprogress.org/kf/biosecurity_a_comprehensive_action_plan.

BiosecurityAustralia.

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): 39-63.

Biosecurity for Agriculture and Food Production. <http://www.fao.org/biosecurity/>

CFIA. http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht_ml

ENT 624

Advanced Insecticide Toxicology

3(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-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.
- 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.
- 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.
- 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.

List of Journals

- ☐ *Agricultural and Forest Entomology*- Royal Entomological Society, UK
- ☐ *Annual Review of Entomology*- Paloalto, 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, Minnessota, 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/bttox.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/fungalatabases/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/fbpps.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>

PLANT PATHOLOGY

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	PPATH 511*	MYCOLOGY	3(2+1)
2.	PPATH 512	DETECTION AND DIAGNOSIS OF PLANT DISEASES	3(0+3)
3	PPATH 513*	PRINCIPLES OF PLANT PATHOLOGY	3(3+0)
4	PPATH 514**	FUNDAMENTALS OF MICROBIOLOGY	3(2+1)
II-Semester			
5.	PPATH 521	DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS	3(2+1)
6.	PPATH 522 *	PLANT BACTERIOLOGY	3(2+1)
7.	PPATH 523	DISEASES OF VEGETABLE AND SPICES CROPS	3(2+1)
8.	PPATH 524	SEED HEALTH TECHNOLOGY	3(2+1)
9.	PPATH 525	CHEMICALS IN PLANT DISEASE MANAGEMENT	3(2+1)
10.	PPATH 526	ECOLOGY OF SOIL-BORNE PLANT PATHOGENS	3(2+1)
11.	PPATH 527	DISEASE RESISTANCE IN PLANTS	3(3+0)
12.	PPATH 528	BIOLOGICAL CONTROL OF PLANT DISEASES	3(2+1)
13.	PPATH 529	INTEGRATED DISEASE MANAGEMENT	3(2+1)
III-Semester			
14.	PPATH 531*	PLANT VIROLOGY	3(2+1)
15	PPATH 532	PRINCIPLES OF PLANT DISEASE MANAGEMENT	3(2+1)
16	PPATH 533	DISEASES OF FIELD AND MEDICINAL CROPS	3(2+1)
17	PPATH 534	EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES	3(2+1)
18.	PPATH 535	POST HARVEST DISEASES	3(2+1)
19.	PPATH 536	INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS	3(2+1)
20.	PPATH 537	MUSHROOM PRODUCTION TECHNOLOGY	3(2+1)
21.	PPATH 538	PLANT QUARANTINE	3(2+1)
IV-Semester			
22.	PPATH 541	SEMINAR	1
23.	PPATH 542	COMPREHENSIVE	2
24.	PPATH 543	RESEARCH	15
Ph.D.			
I-Semester			
1.	PPATH 611	ADVANCED VIROLOGY	3(2+1)
2	PPATH 612*	MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION	3(2+1)
II-Semester			
3.	PPATH 621*	ADVANCED MYCOLOGY	3(2+1)
4.	PPATH 622	ADVANCED BACTERIOLOGY	3(2+1)
5.	PPATH 623	PLANT BIOSECURITY, BIOSAFETY & PRINCIPLES OF CERTIFICATION	3(3+0)
III and onward Semesters			
6.	PPATH 641	SEMINAR	2
7.	PPATH 642	PRELIMINARY	4
8.	PPATH 643	RESEARCH	40

* Core courses ** Compulsory for M.Sc. Biotechnology.

PLANT PATHOLOGY

M.Sc. (Ag.) Programme

PPATH- 511

Mycology

3(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.

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.

PPATH-512

Detection and Diagnosis of Plant Diseases

3(0+3)

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 centrifuge, pH meter, micrometer, haemocytometer, camera lucida.

UNIT III

Microscopic techniques and staining methods, phase contrast system, 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 manuscripts.

Suggested Readings

- Baudoin ABAM, Hooper G R, Mathre D E & Carroll R B. 1990. Laboratory Exercises in Plant Pathology: An Instructional Kit. Scientific Publ., Jodhpur.
- Dhingra O D & Sinclair J B. 1986. Basic Plant Pathology Methods. CRC Press, London, Tokyo.
- Fox R T V. 1993. Principles of Diagnostic Techniques in Plant Pathology. CABI Wallington.
- Mathews R E F. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Boca Raton, Tokyo.
- Pathak V N. 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 R E F. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Florida.
- Noordam D. 1973. Identification of Plant Viruses, Methods and Experiments. Cent. Agric. Pub. Doc. Wageningen.
- Trigiano R N, Windham M T & Windham A S. 2004. Plant Pathology- Concepts and Laboratory Exercises. CRC Press, Florida.
- Chakravarti B P. 2005. Methods of Bacterial Plant Pathology. Agrotech, Udaipur.

PPATH -513

Principles of Plant Pathology

3(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 growth of 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.

Unit III

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

UNIT IV

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

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. Springer Verlag, 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.

PATH-514

Fundamentals of Microbiology

3(2+1)

Objective

To acquaint the students with the basic aspects of microbes and their use in agriculture.

Theory

UNIT I

Scope of Microbiology: groups of microorganisms, distribution of microbes in nature; major fields of microbiology. Concepts of origin of life. History of microbiology- important events in the development of microbiology; Contribution of Leeuwenhoek, Robert Koch, Louis Pasteur, Alexander Fleming and others.

UNIT II

Microscopy: light microscope, phase contrast microscope, electron microscope. Microbial taxonomy: classification system, numerical taxonomy, major characteristics used in taxonomy, kingdom of microorganisms.

UNIT III

Prokaryotic and eukaryotic cell structure and function, microbial nutrition: common nutrient requirement, nutritional types of microorganisms. Growth of microorganisms: growth curve, influence of environmental factors on growth. Viruses: general structure, multiplication and taxonomy.

UNIT IV

Biogeochemical cycling: carbon cycle, nitrogen cycle and sulfur cycle; application of microorganisms in agriculture: biofertilizers and biopesticides.

UNIT V

Industrial microbiology: microbial growth process, culture, medium and growth conditions, strain selection, microbial products.

UNIT VI

Immunology: antigen-antibody reactions, agglutinations, complement fixation, ELISA, immunoprecipitation, serotyping.

UNIT VII

Microbial genetics: genetics of bacteria: transformation, transduction, conjugation, mutation, detection and isolation of mutants, plasmid types and their importance; genetics of fungi.

Practical

Sterilization of glasswares and media. Preparation of culture media; liquid, solid and selective media for growth of microorganisms. Purification and maintenance of microbial culture by pour plate, spread and streak methods. Determination of generation time and growth curve for microorganisms. Determination of carbon and nitrogen requirement for microbial growth. Biochemical tests: Assay of production of amylase, cellulose and

pectolytic enzymes by microorganism. Staining techniques for identification of microbes: simple staining, differential staining and capsule staining.

Suggested readings

Atlas, R.M. 1995. Laboratory manual of experimental microbiology. Mosby year book, Inc. Missouri.

Pelczar Jr., M. J., Chan, E.C.S. and Noel, R. K.1993. Tata McGraw -Hill McGraw-Hill Publishing Company Limited, New Delhi.

Sullia, S. B. and Santharam, 1998. General Microbiology. Oxford and IBH.

P PATH -521 Diseases of Fruits, Plantation and Ornamental Crops 3(2+1)

Objective

To acquaint with diseases of fruits, plantation, ornamental plants caused by fungal, bacterial and viral diseases and their management.

Theory

UNIT I

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm and management of the fruits diseases.

UNIT II

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.

UNIT III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, orchids, marigold, chrysanthemum and their management.

Practical

Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops. Collection and dry preservation of diseased specimens of important crops.

Suggested Readings

Gupta V K & Sharma S K. 2000. *Diseases of Fruit Crops*. Kalyani Publ., NDelhi.

Pathak V N. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi

Singh R S. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Thind, T. S 2001. *Diseases of Fruits and vegetables and Their management*. Kalyani Publishers, Ludhiana.

Walker J C. 2004. *Diseases of Vegetable Crops*. TTPP, India.

P PATH -522 Plant Bacteriology 3(2+1)

Objective

To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional requirements, survival and dissemination.

Theory

UNIT I

History and introduction to phytopathogenic procarya, viz., bacteria, MLOs,

spiroplasmas and other fastidious procarya. Importance of phytopathogenic bacteria.

UNIT II

Evolution, classification and nomenclature of phytopathogenic procarya and list of 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.

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 Plant pathogens and their Management*. Angkor Publ., New Delhi.

Verma JP. 1998. *The Bacteria*. Malhotra Publ. House, New Delhi.

P PATH -523

Diseases of Vegetables and Spices Crops

3(2+1)

Objective

To impart knowledge about symptoms, epidemiology of different diseases of vegetables and spices caused by fungal, bacterial and viral diseases and their management.

Theory

UNIT I

Nature, prevalence, factors affecting disease development of bulb, leafy vegetable, crucifers, cucurbits and solanaceous vegetables. Diseases of protected cultivation.

UNIT II

Symptoms and management of diseases of different root, bulb, leafy vegetables, crucifers, cucurbits and solanaceous vegetable crops.

UNIT III

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger.

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.
 Godara, S.I., Kapoor, BBS and Rathore, B.S. 2010. Madhu Publications, Bikaner-3, India.
 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. 6
 Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

PPATH -524

Seed Health Technology

3(2+1)

Objective

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/losses 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.
 Paul Neergaard. 1988. *Seed Pathology*. MacMillan, London.
 Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

PPATH -525

Chemicals in Plant Disease Management

3(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, nematocides, antiviral chemicals and botanicals.

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 nematocides; *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, N. 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, NY.

Vyas SC. 1993. *Handbook of Systemic Fungicides* Vols. I-III. Tata McGraw Hill, N. Delhi.

PPATH 526**Ecology of Soil-Borne Plant Pathogens****3(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.

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. Isolation and identification of different biocontrol agents.

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 and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

PPATH -527

Disease Resistance in Plants

3(3+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.

Suggested Readings

Deverall BJ. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, NY.

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, NY..
- Van der Plank JE. 1984. *Disease Resistance in Plants*. Academic Press, New York

PPATH -528

Biological Control of Plant Diseases

3(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.

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. Study of cfu/g.

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, Minnesota.
- Fokkema 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.

PPATH -529

Integrated Disease Management

3(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 disease management.

UNIT III

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed- mustard, pearl millet, *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 certain 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.

PPATH- 531

Plant Virology

3(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.

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.

UNIT V

Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, prions. Principles of the working of electron-microscope and ultra-microtome.

UNIT VI

Origin and evolution, mechanism of resistance, genetic engineering, ecology, and listing of important diseases and their management.

Practical

Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, method of raising antisera, serological tests, electron microscopy and ultratome, 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 and Experiments. Oxford & IBH, New Delhi.

PPATH -532

Principles of Plant Disease Management

3(2+1)

Objectives

To acquaint with different strategies for management of plant diseases.

Theory

UNIT I

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanical methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

UNIT II

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.

UNIT III

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

Practical

In vitro and in vivo evaluation of chemicals and bioagents against plant pathogens; ED and MIC values, study of structural and functional details of sprayers and dusters.

Suggested Readings

- 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, N Delhi.

Palti J. 1981. Cultural Practices and Infectious Crop Diseases. Springer- Verlag, New York.

Vyas SC. 1993 Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PPATH -533

Diseases of Field and Medicinal Plants

3(2+1)

Objective

To educate about the nature, prevalence, etiology, factors affecting disease development and control measures of field and medicinal crop diseases caused by fungal, bacterial and viral diseases.

Theory

UNIT I

Diseases of Cereal crops- wheat, barley, rice, pearl millet, sorghum and maize.

UNIT II

Diseases of Pulse crops- gram, urdbean, mothbean, mungbean, lentil, pigeonpea, soybean.

UNIT III

Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

UNIT IV

Diseases of Cash crops- cotton, sugarcane.

UNIT V

Diseases of Fodder legume crops- berseem, oats, guar, lucerne, cowpea.

UNIT VI

Medicinal crops- plantago, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, Aloe vera.

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.

Rangaswami G. 1999. Diseases of Crop Plants in India. 4th Ed. Prentice Hall of India, N Delhi.

Ricanel C, Egan BT, Gillaspie Jr AG & Hughes CG. 1989. Diseases of Sugarcane, Major Diseases. Academic Press, New York.

Singh RS. 2007. Plant Diseases. 8th Ed. Oxford & IBH, New Delhi.

Singh US, Mukhopadhyay AN, Kumar J & Chaube HS. 1992. Plant Diseases of International Importance. Vol. I. Diseases of Cereals and Pulses. Prentice Hall, Englewood Cliffs, New Jersey.

Thind, T.S. 1998. Diseases of field Crops and their management. National Agril. Technology Information Centre, Ludhiana, India.

PPATH -534

Epidemiology and Forecasting of Plant Diseases

3(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 logarithms, 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, NY.

Zadoks JC & Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London.

PPATH -535

Post Harvest Diseases

3(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 pre- harvest 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, rhizosphere 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 Alimentarius 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 V N. 1970. *Diseases of Fruit Crops and their Control*. IBH Publ., N Delhi.
Chaddha K L & Pareek O P. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.

PPATH -536 Insect Vectors of Plant Viruses and other Pathogens 3(2+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 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, 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 theTropics*. English Language Books Series, Longman, London.

PPATH -537

Mushroom Production Technology

3(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.

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* 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 post- harvest 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.

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 disinfection/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.

Ph.D. Programme**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 immuno diagnosis, 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 RNAi dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants.

UNIT VI

Techniques and application of tissue culture. Origin, evolution and inter- relationship 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. *Virus 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, N. Y.

Maramorosch K, Murphy FA & Shatkin AJ. 1996. *Advances in Virus Research*. Vol. 46. Academic Press, New York.

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, New York.

Thresh JM. 2006. *Plant Virus Epidemiology*. Advances in Virus Research 67. Academic Press, New York.

PPATH -612

Molecular Basis of Host- Pathogen Interaction

3(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, N.York.
- Gurr S.J, Mc Pohersen M.J & Bowlos D.J. (Eds.). 1992. *Molecular Plant Pathology - A Practical Approach*. Vols. I & II, Oxford Univ. Press, Oxford.
- Mathew J.D. 2003. *Molecular Plant Pathology*. Bios Scientific Publ., UK.
- Ronald P.C. 2007. *Plant-Pathogen Interactions: Methods in Molecular Biology*. Humana Press, New Jersey.
- Stacey G & Keen T.N. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

PPATH -621

Advanced Mycology

3(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.

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.

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.

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. Ainsworth and Bisby's Dictionary of Fungi. 9th Ed., CABI, Wallington.
- Ulloa M & Hanlin RT. 2000. Illustrated Dictionary of Mycology. APS, St. Paul, Minnesota.
- Webster J & Weber R. 2007. Introduction to Fungi. Cambridge Univ. Press, Cambridge

PPATH -622**Advanced Bacteriology****3(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, exopolysaccharide, 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 pathogens-gene silencing, RNAi 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 profiling of bacteria and variability status; Endospore, Flagellar 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 J.W & Simon P. 2004. Molecular Genetics of Bacteria. John Wiley & Sons, New York.

Garrity G.M, Krieg N.R & Brenner D.. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, New York.
 Gnanamanickam S.S. 2006. Plant-Associated Bacteria. Springer Verlag, New York.
 Mount M.S & Lacy G.H. 1982. Plant Pathogenic Prokaryotes. Vols. I, II. Academic Press, N.Y.
 Sigeo D.C. 1993. Bacterial Plant Pathology: Cell and Molecular Aspects. Cambridge Univ. Press, Cambridge.
 Starr M.P. 1992. The Prokaryotes. Vols. I – IV. Springer Verlag, New York.

PPATH -623 Plant Biosecurity, Biosafety and Principles of Certification 3(3+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 J.E. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, UK.

ISHI-veg *Manual of Seed Health Testing Methods*. http://www.worldseed.org/en-us/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 N.S & Singh S.V. 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.springer.com/life+Sci/agriculture
- www.backwellpublishing.com
- www.csiro.au
- www.annual-reviews.org

NEMATOTOLOGY

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
I-Semester			
1.	NEMAT 511	PRINCIPLES OF NEMATOTOLOGY	3(2+1)
II-Semester			
2.	NEMAT 521	NEMATODE DISEASES OF CROPS	3(2+1)
III-Semester			
3.	NEMAT 531	NEMATODE MANAGEMENT	3(2+1)

NEMA 511

Principles of Nematology

3(2+1)

Objective-

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

Theory-

UNIT-I

History and growth of nematology; nematode habitats and diversity, plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

UNIT-II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

UNIT-III

Types of parasitism, nature of damage and general symptomatology; interaction of plant parasitic nematodes with other organism

UNIT-IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

UNIT-V

Principles and practices of nematode management; integrated nematode management.

Practical-

Studies on kinds of nematodes-free living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining of sedentary endoparasites; examination of different life stages of important plant parasitic nematodes; their symptoms and histopathology.

Suggested Readings-

Dropkin VH. 1980, *An Introduction to Plant Nematology*. John Wiley & Sons, New York.

Perry RN & Sitaramaiah K. 1994. *Plant Pathogens-Nematodes*. Oxford & IBH, New Delhi.

Thorne, G.1961.*Principles of Nematology*. McGraw Hill, New Delhi.

Walia RK & Bajaj HK.2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.

NEMA 521

Nematode Diseases of Crops

3(2+1)

Objective

To impart basic knowledge about the causal organism, nature of damage, symptoms and control of nematode diseases of agricultural and horticultural crops.

Theory

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops.

UNIT-I

Cereal crops-Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum.

UNIT-II

Pulses, sugar, fibre, fodder and oilseed crops-pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugar beet cyst and soybean cyst nematode problems.

UNIT-III

Vegetable crops-root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. Nematode problems of protected cultivation.

UNIT-IV

Fruit crops-roo-knot disease, reniform nematode, slow decline of citrus, mushroom-nematode problems.

UNIT-V

Plantation, medicinal and aromatic crops-burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems coffee and tea, red ring disease of coconut. Forest-pines wilt disease.

Practical-

Diagnosis of causal organisms; identification of different life cycle stages; study of symptoms and histopathology of nematode damage in different crops/ field diagnosis of nematode problems.

Suggested Readings-

Bhatti DS & Walia RK. 1992. *Nematode Pest of Crops*. CBS New Delhi.

Evans AAF, Trudgill DL & Webster JM. 1994. *Plant Parasitic Nematodes in Temperate Agriculture*. CABI, Wallingford

Luc M, Sikora RA & Bridge J. 2005. *Plant Parasitic Nematodes in Sub-Tropical and Tropical Agriculture*. CABI, Wallingford.

Nickle WR, 1991. *Manual of Agricultural Nematology*. Marcel Dekker, New York.

Perry RN & Moens M. 2006. *Plant Nematology*. CABI, Wallingford.

NEMA 531

Nematode Management

3(2+1)

Objective

To impart comprehensive knowledge about the principles and practices of nematode management.

Theory

UNIT-I

Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.

UNIT-II

Chemical methods-nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.

UNIT-III

Cultural practices-crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil; antagonistic and trap crops, sanitation etc. physical methods-use of heat, hot water treatment and other methods of disinfections of plant material.

UNIT-IV

Biological methods-concept and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods-use of antagonistic plants and antinemic plant products..

UNIT-V

Genetic methods-plant resistance; legal methods-quarantine regulations; integrated nematode management-concepts and applications.

Practical-

In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods; methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on bio control potential of fungal, bacterial parasites, and predacious fungi and nematodes.

Suggested Readings

- Bhatt DS & Walia RK. 1994. *Nematode Pest Management in Crops*. CBS, New Delhi.
- Brown RH & Kerry BR. 1987. *Principles and Practices of Nematode Control in crops*. Academic Press, Sydney.
- Chen ZX, Chen SY & Dickson DW. 2004. *Nematology: Advances and Perspectives. Vol. II: Nematode Management and Utilization*. CABI, Wallingford.
- Perry RN & Moens M. 2006. *Plant Nematology*. CABI, Wallingford.
- Starr JL, Cook R & Bridge J. 2002. *Plant Resistance to Parasitic Nematodes*. CABI, Wallingford.
- Whitehead AG. 1997. *Plant Nematode Control*, CABI, Wallingford.

List of Journals

- ☐ *Annals of Applied Nematology* - Society of Nematologists, USA
- ☐ *Current Nematology* - Bioved Research Society, Allahabad, India
- ☐ *Egyptian Journal of Agronematology* – Egyptian Society of Agricultural Nematology
- ☐ *Indian Journal of Nematology* - Nematological Society of India
- ☐ *International Journal of Nematology* - Afro-Asian Society of Nematologists, Luton
- ☐ *Japanese Journal of Nematology* - Japanese Nematological Society
- ☐ *Journal of Nematology* - Society of Nematologists, USA
- ☐ *Journal of Nematode Morphology and Systematics* –Jaen, Universidad de Jaen
- ☐ *Nematologia Brasileira* – Brazilian Nematological Society
- ☐ *Nematologia Mediterranea* – Istituto per la Protezione delle Plante (IPP) – Sect. of Bari of the CNR, Italy
- ☐ *Nematology* - Brill Academic Publishers, UK
- ☐ *Nematropica* - Organization of Nematologists of Tropical America
- ☐ *Pakistan Journal of Nematology* - Pakistan Society of Nematologists
- ☐ *Russian Journal of Nematology* - Russian Society of Nematologists

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- ☐ <http://www.nematologists.org/> (The Society of Nematologists)
- ☐ <http://nematology.ucdavis.edu/> (Deptt. of Nematology, Univ. of California, Davis)
- ☐ <http://www.ifns.org/> (International Federation of Nematology Societies)
- ☐ <http://www.inaav.ba.cnr.it/nemmed.html> (Nematologia Mediterranea)
- ☐ <http://nematode.unl.edu/Nemajob.htm> (Nematology Employment Bulletin Board)
- ☐ <http://nematode.unl.edu/> (University of Nebraska - Lincoln Nematology)
- ☐ <http://nematode.unl.edu/wormsite.htm> (Links to Other Nematology Resources)
- ☐ <http://nematode.unl.edu/SON/jon.htm> (Journal of Nematology)
- ☐ <http://www.nematology.ucr.edu/> (Deptt. of Nematology, Univ. of California, Riverside)
- ☐ <http://entnemdept.ifas.ufl.edu/> (Univ. of Florida, Entomology & Nematology Dept.)
- ☐ http://www.brill.nl/m_catalogue_sub6_id8548.htm (Nematology - journal)
- ☐ http://www.ars.usda.gov/main/site_main.htm?modecode=12752900 (Nematology Lab., USDA)
- ☐ http://flnem.ifas.ufl.edu/HISTORY/nem_history.htm (Nematology history)
- ☐ <http://www.nematology.ugent.be/> (Nematology Unit, Ghent University)
- ☐ <http://www.entm.purdue.edu/nematology/> (The Purdue Nematology Lab.)
- ☐ <http://www.bspp.org.uk/ppigb/nematolo.htm#a-z> (Links to Nematology labs)
- ☐ <http://www.nem.wur.nl/UK/> (Laboratory of Nematology, Wageningen Univ.)
- ☐ <http://onta.ifas.ufl.edu/> (The Organization of Nematologists of Tropical America)
- ☐ <http://nematology.umd.edu/nematology.html> (Plant Nematology Laboratory, Maryland)
- ☐ <http://www.biology.leeds.ac.uk/nem/> (Plant Nematology Lab., University of Leeds)
- ☐ <http://www.plantpath.iastate.edu/dept/labs/tylka/> (Iowa State University, Nematology Lab)
- ☐ <http://nematologists.org.au/newsletters.html> (Australasian Association of Nematologists)
- ☐ <http://soilplantlab.missouri.edu/nematode/> (Plant Nematology Laboratory, Missouri)
- ☐ <http://www.eumaine.ugent.be/> (European Master of Science in Nematology)
- ☐ <http://www.jstage.jst.go.jp/browse/jjn> (The Japanese Journal of Nematology)

EXTENSION EDUCATION

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	EXT 511*	DEVELOPMENT PERSPECTIVES OF EXTENSION EDUCATION	3(2+1)
2.	EXT 512*	DEVELOPMENT COMMUNICATION AND INFORMATION MANAGEMENT	3(2+1)
3	EXT 513*	DIFFUSION AND ADOPTION OF INNOVATIONS	3(2+1)
II-Semester			
4.	EXT 521	E-EXTENSION	3(2+1)
5.	EXT 522	ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT IN EXTENSION	3(2+1)
6.	EXT 523	HUMAN RESOURCE DEVELOPMENT	3(2+1)
7.	EXT 524	PARTICIPATORY METHODS FOR TECHNOLOGY DEVELOPMENT AND TRANSFER	3(2+1)
III-Semester			
8	EXT 531*	RESEARCH METHODS IN BEHAVIORAL SCIENCES	3(2+1)
9.	EXT 532	VISUAL COMMUNICATION	3(2+1)
10.	EXT 533	PERSPECTIVES OF DISTANCE EDUCATION	3(2+1)
11.	EXT 534	GENDER SENSITIZATION FOR DEVELOPMENT	3(2+1)
12.	EXT 535	MARKET-LED EXTENSION	3(2+1)
IV-Semester			
13.	EXT 541	SEMINAR	1
14.	EXT 542	COMPREHENSIVE	2
15.	EXT 543	RESEARCH	15
Ph.D.			
I-Semester			
1.	EXT 611	ADVANCES IN AGRICULTURAL EXTENSION	3(2+1)
2	EXT 612*	ADVANCES IN TRAINING TECHNOLOGY	3(2+1)
3	EXT 613	ORGANIZATIONAL DEVELOPMENT	3(2+1)
II-Semester			
4.	EXT 621*	ADVANCED DESIGN AND TECHNIQUES IN SOCIAL SCIENCE RESEARCH	3(2+1)
5	EXT 622	ADVANCED MANAGEMENT TECHNIQUES	3(2+1)
6	EXT 623	ADVANCED INSTRUCTIONAL TECHNOLOGY	3(2+1)
7	EXT 624	THEORY CONSTRUCTION IN SOCIAL SCIENCES	3(3+0)
8	EXT 625	MEDIA MANAGEMENT	3(2+1)
9	EXT 626	TRANSFER OF TECHNOLOGY IN AGRICULTURE	3(2+1)
III and onward Semesters			
10	EXT 641	SEMINAR	2
11	EXT 642	PRELIMINARY	4
12	EXT 643	RESEARCH	40

***Core courses**

THE FOLLOWING BASIC SUPPORTING COURSES ARE RECOMMENDED FOR M. SC. / Ph. D. PROGRAMMES IN OTHER DEPARTMENTS.

M.Sc(Ag)			
1.	STAT 511	STATISTICAL METHODS	3(2+1)
2.	STAT 522	SAMPLING TECHNIQUES	3(2+1)
Ph. D.			
3	STAT 524	APPLIED REGRESSION ANALYSIS	3(2+1)

EXTENSION EDUCATION

M.Sc. (Ag) Programme

EXT 511 Development Perspectives of Extension Education 3(2+1)

Objective

The course is intended to orient the students with the concept of extension education 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

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

Poverty Alleviation Programmes – SGSY, SGRY, PMGSY, DPAP, DDP, CAPART – Employment Generation Programmes – NREGP, Women Development Programmes – ICDS, MSY, RMK, Problems in Rural Development.

UNIT IV

Current Approaches in Extension: Decentralized Decision Making, Bottom up Planning, Farming System Approach, Farming Situation Based Extension, Market – Led – Extension, Farm Field School, ATIC, Kisan Call Centres, NAIP.

Practical

Visit to Gram Panchayat to study on-going Rural Development Programmes, Visit to KVK, NGO and Extension centers of State Agricultural University and State Departments, Bottom up planning, Report preparation and presentations.

Suggested Readings

- Chandrakandan KM, Senthil Kumar & Swatilaxmi. PS. 2005. *Extension Education What? And What Not ?* RB SA 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 & 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 Publ.

EXT 512 Development Communication and Information Management 3(2+1)

Objective

In this course, students will learn about the concept, meaning and process of communication 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

Communication process – concept, elements and their characteristics – Models and theories of communication – Communication skills– fidelity of communication, 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.

UNIT II

Methods of communication – Meaning and functions, classification. Forms of communication – Oral and written communication, Non-verbal communication, interpersonal communication, organizational 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.

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; Rewriting 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.

Practical

Writing News for Farm News paper/Magazines. Reporting of Various Extension activities like-Field day, Training, Result Demonstration and farmer' fair etc. Preparing and delivering effective speech. Handling of communication and recording equipments (like-Computer, P.A.System & Camera). Script writing for Radio, T.V. Conducting students' visit to Radio & T.V. station

Suggested Readings

Dahama OP & Bhatnagar OP. 2005. *Education and Communication for Development*. Oxford & IBH.

Grover I, Kaushik S, Yadav L & Varma SK. 2002. *Communication and Instructional 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 and Methods*. Oxford & IBH.

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**

Diffusion – concept and meaning, elements; traditions of research on 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 – a critical appraisal of the new formulation.

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.

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, he studies various ICT projects which are successful in delivering the services to the clientele fulfilling the objective of Transfer of Technology i.e. Reaching the unreached.

TheoryUNIT 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. ICT use in 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.

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

Agri.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.

**EXT 522 Entrepreneurship Development and Management in
Extension**

3(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.

TheoryUNIT I

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

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 III

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.

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; 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 Skills 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 ongoing 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 Human Resource Management*. ICFAI, Hyderabad.
 Tripathi & Reddy. 2004. *Principles of Management*. Tata McGraw-Hill.
 Wayne MR & Robert MN. 2005. *Human Resource Management*. International Ed. Pearson Prentice Hall.

EXT 524 Participatory Methods for Technology Development and Transfer 3(2+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 – 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 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 space related methods, time related method 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.

EXT 531 Research Methods In Behavioural Science 3(2+1)

Objective

This course is designed with a view to provide knowledge and skills in methods of behavioural sciences research and student will learn the 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 work development 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, Use of appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research. Validity – Meaning and methods of testing. Reliability – Meaning 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, Maximincon Principle, Sampling – Types of sampling and sampling procedures.

UNIT III

Research Designs – Meaning, purpose and criteria for research design, Types, advantages and limitations of each design. Experimental design – Advantages and limitations. Data Collection devices - 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 and advantages and limitations. 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.

UNIT IV

Data processing – Meaning, coding, preparation of master code sheet, analysis and tabulation of data, 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.- Pre-testing of the data collection instrument-Techniques of interviewing and collection of data using the data collection instruments-Data processing, 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 Radings

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.

EXT 532

Visual Communication

3(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 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 material 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 of visuals & graphics. 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. Digitized video material in multimedia production. Designing visuals for print and 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 Harclerod. 1952. *A.V. Instructional Material & Methods*. Mc.Graw Hill.

Reddy YN. 1998. *Audio Visual Aids in Teaching, Training and Extension*. Haritha Publ. House, Hyderabad.

Objective

The course is intended to orient 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*. Routledge 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.

Objective

In this course the students will learn about an overview of the concept of gender and gender balance on development and develop skills of identifying gender roles, 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 concepts, issues and challenges in development; Gender roles, gender balance, status, need and scope; Gender analysis tools and techniques.

UNIT II

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.

EXT 535

Market Led Extension Management

3(2+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, multilevel 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 led extension; Contact farming – a viable approach to meet market challenges; IT enabled 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 & 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 Programme

EXT 611

Advances in Agricultural Extension

3(2+1)

Objective

By the End of the course 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 extension services 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. Learning 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*. Intermediate Technology Publ.

Crouch BR & Chamala S. 1981. *Extension Education and Rural Development*. Macmillan.

John KC, Sharma DK, Rajan CS & Singh C. 1997. *Farmers Participation in Agricultural 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.

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.

TheoryUNIT 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, Designing experiential training sessions, simulation exercises, and openness in training transaction - managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees).

UNIT III

Recent Training Techniques for understanding and facilitation 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.

Objective

By the end of the course student will be able to-- Understand & Study the Organization in terms of types, Characteristics, Needs, Motives, Organization behaviour, Organization Communication, Organization development and Individual behaviour in organization. To

analyse 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 Behaviour - Context and concept - levels of organizations - formal and 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 - divisionalisation - 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 of development 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 organisations and drawing factors for organizational effectiveness.

Suggested Readings

- Ancona, Kochaw, Scully, Van Maanen, Westney 1999. *Organizational Behaviour and Processes*. South Western College Publ., New York.
- Banerjee M. 1984. *Organizational Behaviour*. Allied Publ.
- Deka GC. 1999. *Organizational Behaviour - A Conceptual Application Approach*. Kanishka Publ.
- Dwivedi RS. 2006. *Human Relations and Organization Behaviour- A Global Perspective*. 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. Prentice Hall of India.

EXT 621 Advanced Designs and Techniques in Social Science Research 3(2+1)

Objective

By the End of the course student will be able to-- Develop & Standardize Attitude scale using different techniques of attitude scale construction. Develop skills for using Projected & Semi- Projected Techniques, in Extension Research.

Theory

UNIT I

Scaling technique - 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. Sociometrics, content analysis, case studies, Semantic differential technique.

UNIT II

Projective and Semi projective techniques, Critical incident techniques. Knowledge scale measurement. Participatory tools and techniques in behaviour Research - Data collection and Evaluation. Impact 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. 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 for Relationships*. Wiemil Harper & Row.
- Wilkinson TS & Bhandarkar PL. 2002. *Methodology and Techniques of Social Research*. Himalaya Publ. House.

Objective

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 & 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 Course 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, inter-group conflict, resolving techniques. Conflict 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 on forecasting 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 & Laudén 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.

Objective

By the end of the course student will be able to-- Understand Agricultural Education Scenario in the country and Curriculum development process. Plan & Prepare and present course outline, Lesson Plan & Skill plan. Develop appropriate Teaching & Learning Styles. Use innovative instructional aids & methods.

Theory**UNIT I**

Concepts in Instructional Technology, 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. Motivation of students.

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 & practical with 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 Approach*. 2nd Ed. Charles E. Merrill Publ.
- Joyce 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.

EXT 624**Theory Constructions in Social Sciences****3(3+0)****Objective**

By the end of the course 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 and Rules. 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

Stinchcombe AL. *Construction of Sociological Theories*. Harcourt, Brace & World.

Wionton CA. *Theory and Measurement in Sociology*. John Wiley & Sons.

EXT 625

Media Management

3(2+1)

Objective

To familiarize the students with the working of print, electronic, New Media & 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 farm Video 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 IT in Agriculture. Use of Modern Communication Medium- Electronic Video, Teletext, tele conference, Computer assisted instruction, Video conferencing, - Features, Advantages, Limitations and risk factors 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 management organizations 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 & Kishore Kumar N. 2008. *Farm Journalism in Media Management*. Agro-Tech Publ. Academy.
- Chatterjee 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 Tommorrow*. 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.

Objective

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 attributes of selected fast spreading technologies and slow technologies, study of constraints in 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; Need for Strengthening Cooperation*. Gitanjali Publ. House.
- Dunn DD. 1978. *Appropriate Technology With a Human Face*. Macmillan Press.
- Kapoor SK, Roy PB & Roy AK. 1980. *Role of Information Centres in Technology Transfer*. 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 Developing Countries*. 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)

AGRICULTURAL ECONOMICS

Semester Wise Distribution of Courses

S.No.	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	AGECON 511*	MICRO ECONOMIC THEORY AND APPLICATIONS	3(3+0)
2.	AGECON 512*	MACRO ECONOMICS AND POLICY	3(3+0)
3	AGECON 513*	AGRICULTURAL PRODUCTION ECONOMICS	3(2+1)
II-Semester			
4.	AGECON 521	AGRICULTURAL MARKETING AND PRICE ANALYSIS	3(2+1)
5	AGECON 522	RESEARCH METHODOLOGY FOR SOCIAL SCIENCES	3(2+1)
6	AGECON 523	ECONOMETRICS	3(2+1)
7.	AGECON 524	INTERNATIONAL ECONOMICS	3(2+1)
8.	AGECON 525	LINEAR PROGRAMMING	3(2+1)
III-Semester			
11.	AGECON 531	AGRICULTURAL FINANCE AND PROJECT MANAGEMENT	3(2+1)
12.	AGECON 532	AGRICULTURAL DEVELOPMENT AND POLICIES	3(3+0)
13.	AGECON 533	NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS	3(2+1)
14.	AGECON 534	EVOLUTION OF ECONOMIC THOUGHT	3(3+0)
IV-Semester			
16.	AGECON 541	SEMINAR	1
17.	AGECON 542	COMPREHENSIVE	2
18.	AGECON 543	RESEARCH	15
Ph.D.			
I-Semester			
1.	AGECON 611*	ADVANCED MICRO-ECONOMIC ANALYSIS	3(3+0)
2	AGECON 612*	ADVANCED MACRO-ECONOMIC ANALYSIS	3(3+0)
3	AGECON 613	NATURAL RESOURCE MANAGEMENT	3(2+1)
4	AGECON 614	ADVANCED ECONOMETRICS	3(2+1)
II-Semester			
4.	AGECON 621	ADVANCED AGRICULTURAL MARKETING AND PRICE ANALYSIS	3(2+1)
5	AGECON 622	ADVANCED PRODUCTION ECONOMICS	3(2+1)
6	AGECON 623	COMMODITY FUTURES TRADING	3(3+0)
7	AGECON 624	QUANTITATIVE DEVELOPMENT POLICY ANALYSIS	3(2+1)
III and onward Semesters			
8	AG ECON 641	SEMINAR	2
9	AG ECON 642	PRELIMINARY	4
10	AG ECON 643	RESEARCH	40

* Core courses

AGRICULTURAL ECONOMICS

M Sc. (Ag) Programme

AG ECON 511 Micro Economic Theory and Applications 3(3+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 – Elasticity 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

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 K.K. 2002. *Modern Economic Theory* . Sultan Chand & Co.
Henderson J.M & Quandt R.E. 2000. *Microeconomic Theory: A Mathematical Approach* . McGraw-Hill.
Jhingan, M.L. 2004. *Micro Economic Theory*. Vikash Publishing House Pvt. Ltd. New Delhi.
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.

AG ECON 512 Macro Economics and Policy 3(3+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 classical and 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 H.L. 2007. *Macroeconomics: Theory and Policy* . S. Chand & Co.

Eugene A Diulio 2006. *Macroeconomics* . 4 Ed. Schaums' Outlines. th

Gardner Ackely 1987. *Macro Economic: Theory and Policy* . Collier Macmillan.

Dornbusch. 2006. *Macroeconomics* . McGraw Hill Publication.

AG ECON 513

Agricultural Production Economics

3(2+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.

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 scale.

Suggested Readings

Beattie B.R & Taylor C.R. 1985. *The Economics of Production* . John Wiley & Sons.

Doll J.P & Frank O. 1978. *Production Economics - Theory and Applications* . John Wiley & Sons.

Gardner B.L & Rauser G.C. 2001. *Handbook of Agricultural Economics* Vol. I. *Agricultural Production* . Elsevier.

Heady E.O. *Economics of Agricultural Production and Resource Use* .Prentice-Hall.

Sankayan P.L. 1983. *Introduction to Farm Management* . Tata Mc Graw Hill.

AG ECON 521

Agricultural Marketing and Price Analysis

3(2+1)

Objective

To impart adequate knowledge and analytical skills in the field of agricultural marketing 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 co-ordination.

UNIT II

Marketing Co-operatives – APMC Regulated Markets - Direct marketing, Contract farming and Retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -Performance and Strategies - Market infrastructure needs, performance and Government role.

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. 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.

Suggested Readings

Purecell W.D & Koontz S.R. 1999. *Agricultural Futures and Options: Principles and Strategies* .

2nd Ed. Prentice-Hall.

Rhodes V.J. 1978. *The Agricultural Marketing System* . Grid Publ., Ohio.

Shepherd S.G & Gene A.F. 1982. *Marketing Farm Products* . Iowa State Univ. Press.

Singhal A.K. 1986. *Agricultural Marketing in India* . Annual Publ., New Delhi.

AG ECON 522

Research Methodology for Social Sciences

3(2+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

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 III

Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose. Research design and techniques – Types of research design.

UNIT IV

Hypothesis – meaning - characteristics - types of hypothesis – review of literature – setting of Course Objective and hypotheses - testing of hypothesis.

UNIT V

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. Preparation of interview schedule - Field testing. Method of conducting survey. 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 T.R. 1993. *Evaluating Social Science Research - An Introduction* . SAGE Publ.

- Creswell J.W. 1999. *Research Design - Qualitative and Quantitative Approaches*. SAGE Publ.
- Dhondyal S.P. 1997. *Research Methodology in Social Sciences and Essentials of Thesis Writing*. Amman Publ. House, New Delhi.
- Kothari C.R. 2004. *Research Methodology - Methods and Techniques*. Wishwa Prakashan, Chennai.
- Rao K.V. 1993. *Research Methodology in Commerce and Management*. Sterling Publ., New Delhi.
- Singh A.K. 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.

AG ECON 523

Econometrics

3(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 interpretation- approaches to estimation - OLS and their properties -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- specification, estimation and interpretation.

UNIT V

Simultaneous equation models - 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 D.N. 2003. *Basic Econometrics*. McGraw Hill.
- Johnson A.G Jr., Johnson M.B & Buse RC. 1990. *Econometrics - Basic and Applied*. MacMillan.
- Kelejan H.H & Oates WE. 1994. *Introduction to Econometrics Principles and Applications*. Harper and Row Publ.
- Koutsoyianis A. 1997. *Theory of Econometrics*. Barner & Noble.

Maddala G.S. 1992. *Introduction to Econometrics* . MacMillan.
 Maddala G.S. 1997. *Econometrics*. McGraw Hill.
 Pindyck R.S & Rubinfeld D.L. 1990. *Econometrics Models and Econometric Forecasts* . McGraw Hill.

AGECON 524

International Economics

3(2+1)

Objective

The expected outcome of this course will be creating awareness among the students 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

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.

UNIT V

IMF, World Bank, IDA, IFC, ADB – International Trade agreements – Uruguay Round – GATT – WTO.

Practical

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 Restraints on National Welfare- Estimation of trade Equilibrium under Heckscher -Ohlin model.

Suggested Readings

Apple Yard D.R & Field A.J Jr. 1995. *International Economics - Trade, Theory and Policy*. Irwin, Chicago.
 Cherunilam F. 1998. *International Economics* . Tata McGraw Hill.
 Krugman P.R & Obstfeld M. 2000. *International Economics – Theory and Policy* . Addison-Wesley.

AG ECON 525

Linear Programming

3(2+1)

Objective

The objective of the course is 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 minimization problems. Formulation of farm and non farm problems as linear programming models and solutions.

UNIT III

Extension of Linear Programming models.

UNIT IV

Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies.

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 N.P. 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.

AG ECON 531

Agricultural Finance and Project Management

3(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 of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals.

UNIT III

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

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. Network 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

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 P.R. 1986. *Policy and Performance - Agricultural and Rural Development in Post Independent India* . Sage Publ.

Gittinger J.P 1982. *Economic Analysis of Agricultural Projects*. The Johns Hopkins Univ. Press.

Gupta S.C. 1987. *Development Banking for Rural Development* . Deep & Deep Publ.

Little I.M.D & Mirlees J.A. 1974. *Project Appraisal and Planning for Developing Countries*. Oxford & IBH Publ.

Muniraj R. 1987. *Farm Finance for Development*. Oxford & IBH Publ

AG ECON 532

Agricultural Development and Policies

3(3+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. 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 – Marxian model, Schumpeter, Lewis Model. 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 R.M. 1986. *Under Development and Choices in Agriculture* Heritage Publ., New Delhi.

Diwett K.K. 2002. *Modern Economic Theory*. S. Chand & Co.

Eicher K.C & Staats J.M. 1998. *International Agricultural Development*. Johns Hopkins Univ. Press.

Frank E. 1992. *Agricultural Policies in Developing Countries*. Cambridge Univ. Press.

Ghatak S & Ingersent K. 1984. *Agriculture and Economic Development*. Select Book Service Syndicate, New Delhi.

Jhingan M.L. 1998. *The Economics of Development and Planning*. Vrinda Publ.

Jules P.N. 1995. *Regenerating Agriculture – Policies and Practice for Sustainability and Self Reliance*. Vikas Publ. House.

Naqvi S.N.H. 2002. *Development Economics – Nature and Significance*. Sage Publ.

AG ECON 533 Natural Resource and Environmental Economics 3(2+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 Ricardian 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, sustainability, 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, E.I Serafy S & Lutz E. (Eds.). 1989. Environmental Accounting for Sustainable Development. World Bank.

Freeman A.M. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future Press, Baltimore.

Hackett S.C. 2001. *Environmental and Natural Resource Economics: Theory, Policy, and the Sustainable Society*. M. E. Sharpe, Armonk, NY.

Hartwick J.M & Olewiler N.D. 1998. *The Economics of Natural Resource Use*. 2ndEd. Addison-Wesley Educational Publ.

Kerr J.M, Marothia D.K, Katar Singh, Ramasamy C & Bentley W.R. 1997. *Natural Resource Economics: Theory and Applications in India*. Oxford & IBH.

Kolstad C.D. 2000. Environmental Economics. Oxford Univ. Press.

Pearce D.W & 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*. 6 Ed. Addison Wesley.

AG ECON 534

Evolution of Economic Thought

3(3+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 Marxian Economic Ideas. Origins of Formal Microeconomic Analysis

UNIT III

The birth of neoclassical economic thought – Marshall and Walras – General Equilibrium Theory - Welfare Theory – Keynesian economics.

UNIT IV

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.

UNIT V

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.

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 R.B & Hebert R.F. 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.

Ph.D Programme

AGECON 611

Advanced Micro Economic Analysis

3(3+0)

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.

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.

UNIT II

Perfect competition – Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly - Cournot model, Chamberlin model.

UNIT III

General equilibrium theory – Conceptual overview - General equilibrium conditions with Production and Consumption. Existence, Uniqueness and Stability of general competitive 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.

Suggested Readings

Chiang A.C. 1981. *Fundamental Methods of Mathematical Economics*. McGraw-Hill.

Henderson J.M & Quandt R.E. *Microeconomic Theory: A Mathematical Approach*. McGraw-Hill.

Koutsoyiannis A. 2003. *Modern Microeconomics*. The Macmillan Press.

Kreps D.M. 1990. *A Course in Microeconomic Theory*. Princeton Univ. Press.

Silberberg E & Suen W. 2001. *The Structure of Economics – A Mathematical Analysis*. McGraw-Hill.

Varian H.R. 1992. *Microeconomic Analysis*. W.W Norton & Co.

Varian H.R. 1999. *Intermediate Microeconomics*. Affiliated East-West Press.

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 demand 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 E.A. 2006. *Macroeconomics*. 4th Ed. Schaums' Outlines.

Frogon R.T. 1999. *Macro Economic: Theory and Policies*. 6th Ed. Prentice Hall.

Samuelson P.A & Nordhaus WD. 2004. *Economics* . McGraw-Hill.

Shapiro E. 1989. *Macro Economic Analysis*. Galgotia Publ

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).

Theory

UNIT I

Natural resources - definition - characteristics and classification. Stock dynamics of renewable and non-renewable resources. Equation of motion for renewable and non-IT 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.

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.

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 two-period 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 J.P. 1996. *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* Clarendon Press and FAO.

Carlson G.A, Miranowski J & Zilberman D. 1998. *Agricultural and Environmental Resource Economics* . Oxford Univ. Press.

Chiang A.C. 1992. *Elements of Dynamic Optimization* . Waveland Press.

Clark C.W. 1976. *Mathematical Bioeconomics: The Optimal Management of Renewable Resources* . John Wiley and Sons.

Conrad J.M & Clark C.W. 1997. *Natural Resource Economics: Notes and Problems*. Cambridge Univ. Press.

Conrad J.M. 1999. *Resource Economics* . Cambridge University Press.

Fisher A.C. 1981. *Resource and Environmental Economics*. Cambridge Univ. Press.

Prato T. 1998. *Natural Resource and Environmental Economics*. Iowa State Univ. Press.

Stern T. 2003. *Policy Instruments for Environmental and Natural Resource Management*. Resources for the Future, Washington DC.

AG ECON 614

Advanced Econometrics

3(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 likelihood method - errors in variables.

UNIT III

Dummy variables - Qualitative and truncated dependent variables – limited dependent variables –LPM, probit and logit models.

UNIT IV

Autoregressive distributed lag models – panel data fixed and random effects models.

UNIT V

Simultaneous equation methods –identification – estimation.

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 W.H. 2002. *Econometric Analysis*. Pearson Edu.

Johnston J & Dinardo J. 2000. *Econometric Methods*. McGraw-Hill.

Kelejan H.H & Oates WE. 2001. *Introduction to Econometrics Principles and Applications*. Harper & Row.

Maddala G.S. 2002. *Econometrics*. McGraw Hill.

AG ECON 621 Advanced Agricultural Marketing and Price Analysis 3(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 marketing- advantages and disadvantages - quantitative estimation – the distinguishing 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 J.N. 1998. *Agricultural Prices and Commodity Market Analysis*. McGraw-Hill

Goodwin J.W. 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. R.A. 2001. *Economics of Agricultural Markets*. Pearson.

Timmer .C.P. 1986. *Getting Prices Right*. Cornell University Press.

Tomek W.G & Robinson K.L. 2003. *Agricultural Product Prices*. 4th Ed. Cornell University Press.

AG ECON 622

Advanced Production Economics

3(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 planning- methods/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, 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 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. Principles and derivation of demand and supply functions .

UNIT IV

Technology, input use and factor shares -effect of technology on input use- decomposition 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.

UNIT V

Simulation and programming techniques in agricultural production.

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. Estimation of factor shares from empirical functions estimated. Decomposition analysis. Simulation models for agricultural production decisions.

Suggested Readings

Chambers R.G. 1988. *Applied Production Analysis* . Cambridge Univ. Press.

Gardner B.L & Raussier G.C. 2001. *Handbook of Agricultural Economics*.Vol. IA *Agricultural Production*. Elsevier.

Palanisami K.P, Paramasivam & Ranganathan CR. 2002. *Agricultural Production Economics: Analytical Methods and Applications* Associated Publishing Co.

AG ECON 623

Commodity Futures Trading

3(3+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 as price 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 P.J. 1986. *The Concise Handbook of Futures Markets* . John Wiley & Sons.

Leuthold R.M, Junkus J.C & Cordier J.E. 1989. *The Theory and Practice of Futures Markets*. Lexington Books.

Lofton T. 1993. *Getting Started in Futures* . 3rd Ed. John Wiley & Sons.

Purcell W.D. 1991. *Agricultural Futures and Options: Principles and Strategies*. Macmillan Publ.

Wasendorf R.R & McCafferty. 1993. *All about Commodities from the Inside Out*.

McGraw-Hill.

AG ECON 624

Quantitative Development Policy Analysis

3(2+1)

Objectives:

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 elasticity's in making QDPA more meaningful.

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.

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.

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.

Suggested Readings

Chenery H & Srinivasan T.N. (Eds.). 1988. *Hand book of Development Economics*. North-Holland.

Eicher K.C & Staatz J.M. 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 Policies in Developing Countries*. Cambridge Univ. Press.

Ghatak S & Ingersent K. 1984. *Agriculture and Economic Development*. Select Book Service Syndicate.

Kindleberger P.C. 1977. *Economic Development*. McGraw Hill.

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

e-Journals

- 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.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)
- www.ncap.res.in (National Centre for Agril. 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.assochem.org (Associated Chambers of Commerce and Industry of India)
- www.apeda.com (Agril. and Processed Food Products Export Devel. Autho)
- www.mpeda.com (Marine Products Export Development Authority)

STATISTICS

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
I-Semester			
1.	MATH 511	MATHEMATICAL METHODS FOR APPLIED SCIENCES	3(3+0)
2.	STAT 511	STATISTICAL METHODS FOR APPLIED SCIENCES	3 (2+1)
II-Semester			
3.	STAT 521	EXPERIMENTAL DESIGNS	3 (2+1)
4.	STAT 522	SAMPLING TECHNIQUES	3 (2+1)
5.	STAT 523	DATA ANALYSIS USING STATISTICAL PACKAGES	3 (2+1)
6.	STAT 524	APPLIED REGRESSION ANALYSIS	3 (2+1)
III-Semester			
7.	STAT 531	TIME SERIES ANALYSIS	3 (2+1)

MATH-511

Mathematical Methods

3 (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. The students would get an exposure to differentiation, integration and differential equation.

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, etc.

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, engineering, etc.

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.

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

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, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. 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.

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.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F ; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis, Nonparametric tests.

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>.

STAT 521

Experimental Designs

3(2+1)

Objective

This course is meant for students of agricultural and animal sciences other than 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 missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

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; Analysis of resolvable designs; Fitting of response surfaces.

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 Publ.

Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

Design Resources Server: www.iasri.res.in/design.

STAT 522

Sampling Techniques

3(2+1)

Objective

This course is meant for students of agricultural and animal sciences other than 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.

UNIT II

Simple random sampling, sampling for proportion, determination of sample size; inverse sampling, Stratified sampling.

UNIT III

Cluster sampling, PPS sampling, Multi-stage sampling, double sampling, systematic sampling; Use of auxiliary information at estimation as well as selection stages.

UNIT IV

Ratio and regression estimators. Construction and analysis of survey designs, sampling and non-sampling errors; Preparation of questionnaire Non-sampling errors.

Practical

Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.; simple random sampling, determination of sample size; Exercises on inverse sampling, 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*. IASRI Publ.

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.

STAT 523

Data Analysis Using Statistical Packages

3(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, Analyzing crossed and nested classified designs.

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; Spatial analysis; Neural networks.

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, pair wise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE; Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, 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, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

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, Belmont, 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.

STAT 524

Applied Regression Analysis

3(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. This course would prepare students to handle their data for analysis and interpretation.

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; regression approach applied to analysis of variance in one way classification.

UNIT IV

Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

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, fitting of orthogonal polynomials.

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.

STAT 531

Time Series Analysis

3(2+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.

List of Journals
Statistics / Agricultural Statistics / Bio-Statistics

- 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

PLANT PHYSIOLOGY

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	PPHYS 511 [*]	PRINCIPLES OF PLANT PHYSIOLOGY	3(3+0)
2.	PPHYS 512 [*]	PLANT WATER RELATIONSHIP	3(2+1)
3.	PPHYS 513 [*]	TECHNIQUES IN PLANT PHYSIOLOGY	3(2+1)
4.	PPHYS 514	MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION	3(2+1)
II- Semester			
5.	PPHYS 521 [*]	PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO BIOTIC STRESSES	3(2+1)
6.	PPHYS 522 [*]	PHYSIOLOGY OF GROWTH AND YIELD AND MODELING	3(2+1)
7.	PPHYS 523 [*]	SEED PHYSIOLOGY	3(2+1)
8.	PPHYS 524 [*]	MINERAL NUTRITION	3(3+0)
III- Semester			
9.	PPHYS 531 [*]	HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT	3(2+1)
10.	PPHYS 532 [*]	PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS- CARBON AND NITROGEN ASSIMILATION	3(2+1)
11.	PPHYS 533 [*]	POST HARVEST PHYSIOLOGY	3(2+1)
12.	PPHYS 534	CLIMATE CHANGE AND CROP GROWTH	3(3+0)
IV- Semester			
13.	PPHYS 541 [*]	SEMINAR	1
14.	PPHYS 542 [*]	COMPREHENSIVE	2
15.	PPHYS 543 [*]	RESEARCH	15

PLANT PHYSIOLOGY

M.Sc.(Ag) Programme

PPPHYS 511

Principles of Plant Physiology

3(3+0)

Objective

To acquaint the students with the basic concepts of plant physiology 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

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, Mycorrhizal association on water uptake.

UNIT IV

Stomata structure and function – mechanism of stomatal movement, antitranspirants.

UNIT V

Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

UNIT VI

Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants.

UNIT VII

The role of mineral nutrients in plant metabolism, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

UNIT VIII

Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO₂ reduction in Calvin cycle, supplementary pathway of C fixation in C₄ and CAM plants and its significance.

UNIT IX

Photorespiration and its relevance. Photosynthesis as a diffusive process effect of environmental factors on photosynthetic rates, Translocation of photosynthates and its importance in sink growth.

UNIT X

Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.

UNIT XI

Nitrogen metabolism: Inorganic nitrogen species (N₂, NO₃ and NH₃) and their reduction to aminoacids, protein synthesis and nucleic acids.

UNIT XII

Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominance, senescence, fruit growth, abscission.

UNIT XIII

Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering- Photoperiodism and Vernalisation.

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.

PPHYS 512

Plant Water Relationship

3(2+1)

Objective

To acquaint the students within modern concepts of relationships of plants and water in relation to crop and plant productivity.

Theory

UNIT I

Properties of water and aqueous system solutions, colloids, unique and colligative properties.

UNIT II

Movement of water in soil-plant atmosphere continuum (SPAC)

UNIT III

Various resistances

UNIT IV

Water relations of an individual cell-old and new terminology, water potential and inter-relationships among components.

UNIT V

Methods of measurement of parameters of plant water relationships.

UNIT VI

Water absorption

UNIT VII

Ascent of sap

UNIT VIII

Transpiration, physical and biological components

UNIT IX

Physiological and ecophysiological aspects of stomatal movement

UNIT X

Antitranspirants

UNIT XI

Water deficit and its effect on plant processes

Practical

Measurement of relative water content, water potential, osmotic potential, rate of transpiration, stomatal aperture and stomatal frequency, computation of turgor potential, potential evapotranspiration, vapour pressure deficit,

Suggested Readings

Amar Singh 1982. *Practical Plant Physiology*, Kalyani Publishers. Ludhiana and New Delhi

B.Slavik 1974. *Methods in Plant Water Relations*, Springer-Verlag, Berlin and New York.

F.B.Salisbury and C.W.Ross 1992. *Plant Physiology*, Thompson Information Publishing Group Colorado, USA.

O.I. Lange, I. Kappen and E.D. Schulze 1976. *Water and Plant Life*, Springer, Verlag-Berlin and New York.

P.J.Kramer 1983. *Water relations of plants*. Academic Press. New York and London.

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,

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, chlorophyll fluorescence measurements (with the condition that suitable instrument is provided in the department), Estimation of water use efficiency at whole plant and single leaf level. DNA & RNA isolation. Preparation of solutions and buffers, estimation of carbohydrates (reducing and non-reducing sugars), determination of proteins, measurement of electrical conductivity.

Suggested Readings

Dhopte MA & Manuael Livera M. 1986. *Useful Techniques for Plant Scientists*. Forum for Plant Physiologists, R. D. G., Aloka.

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 : Introduction 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 ethylene 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.

PPHYS 521 Physiological and Molecular Responses of Plants to Abiotic Stresses 3(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

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 III

Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products.

UNIT IV

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 V

High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's.

UNIT VI

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 VII

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, Stress imposition and quantification, Stress –stomatal conductance. Canopy temperature as a reflection of transpiration and root activity, Water use – efficiency, Heat and salt tolerance and membrane integrity.

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.

PPHYS 522

Physiology of Growth and Yield and Modeling

3(2+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.

UNIT IX

Crop physiological aspects of wheat, sorghum, millets, pulses, oil seeds, and cotton crops. Six to Eight Species could be chosen based on local importance.

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 energy intercepted, and realized.

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: A Mathematical Approach to Plant and Crop Physiology*. Blackburn Press.

PPHYS 523

Seed Physiology

3(2+1)

Objective

To apprise 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

Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds.

UNIT IV

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 V

Control processes in mobilization of stored resources, Role of embryonic axes, Gibberellin and α -amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins.

UNIT VI

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, Alpha-amylase activity in germinating seeds, Role of GA in inducing amylase activity, Role of embryo in GA induced amylase activity, Protease and lipase activity in germinating seeds, Seed viability test and accelerated ageing test. Seed ardening/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.

PPHYS 524

Mineral Nutrition

3(3+0)

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 ransporters 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, Sulphur, Iron and Zinc efficient crop varieties.

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.

PPHYS 531

Hormonal Regulation of Plant Growth and Development

3(2+1)

Objective

To apprise the students about structure function of plant growth regulator on growth and development of plant.

Theory

UNIT I

Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. triconanol, 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, Gibberellins, cytokinins, Abscissic acid and Ethylene Brassinosteroids.

UNIT III

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, Abscissic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening.

UNIT IV

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 V

Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

Practical

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- cytokinin effect on apical dormance and senescence, ABA bioassay estimation. ABA effect on stomatal movement, Ethylene bioassays, estimation using physico chemical techniques (with the condition that GLC/ HPLC is provided) - effect of hormones on 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. eds JB. (Eds.). 2007.

Functional-Structural Plant Modelling in Crop Production.

Vol. XXII. Springer.

PPHYS 532

Physiological and Molecular Aspects of Photosynthesis- 3(2+1) Carbon and Nitrogen Assimilation

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 r_a , r_s and r_m . 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 non-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, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates –gas exchange. A, gs, Ci, A/gs, C/gs- intrinsic WUE by gas exchange rates. Light, CO₂, VPD response curves, Determination of photorespiration by gas exchange- (with the condition that suitable equipments are provided in the department). Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception.

Suggested Readings

Edwin Oxlade & Graham Lawler. *Plant Physiology: The Structure of 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.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PPHYS 533

Post Harvest Physiology

3(2+1)

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.

Practical

Physiological and biochemical changes during senescence and ripening, Estimation of ethylene during senescence and ripening (with the condition that GLC/ HPLC is provided in the department), determination of Reactive Oxygen Species and scavenging enzymes, Estimation of ripening related enzyme activity, Cellulases pectin methyl esterases, polygalacturonase etc.

Suggested Readings

Jeffrey K Brecht & Weichmann J. 2003. *Post Harvest Physiology and Pathology of Vegetables*. CRC Press.

PPHYS 534

Climate Change and Crop Growth

3(3+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.

List of Journals

- American Journal of Botany
- Annals of Arid Zone
- Annual Review of Plant Physiology and Plant Molecular Biology
- Australian Journal of Agricultural Research
- Australian Journal of Biological Sciences
- Australian Journal of Botany
- Australian Journal of Plant Physiology
- Biochemie und Physiologie der Pflanzen
- Biologia Plantarum
- Botanical Gazette
- Botanical Review
- Canadian Journal of Agricultural Research
- Canadian Journal of Botany
- Canadian Journal of Plant Science
- Communications in Soil Science and Plant Analysis
- Current Science
- Environmental and Experimental Botany
- Euphytica
- Experimental Agriculture
- Experimental Cell Biology
- Functional Plant Biology
- Indian Journal of Agriculture
- Indian Journal of Experimental Biology
- Indian Journal of Plant Physiology
- International Journal of Botany
- Japanese Journal of Crop Science
- Journal of Agricultural and Scientific Research
- Journal of Agricultural Science

- Journal of Arid Environment
- Journal of Experimental Botany
- Journal of Plant Biology
- Journal of Plant Nutrition
- Nature
- New Physiologist
- Physiologia Plantarum
- Physiology and Molecular Biology of Plants
- Plant and Cell Physiology
- Plant and Soils
- Plant Cell, Tissue and Organ Culture
- Plant Growth Regulator abstracts
- Plant Physiology and Biochemistry
- Plant Science
- Plant Science (India)
- Science Journal
- Seed Science and Technology
- Seed Science Research
- Soil Science and Plant Nutrition
- Soviet Plant Physiology
- Trends in Plant Science
- Tropical Agriculture

e-Resources

- www.Bioone Online Journals The Arabiopsis Book.
- [www. Botany](http://www.Botany) on line:
- www.Ingenta Connect Physiologia Plantarum
- www.new.phytologist.org.
- www.plantphysiol.org.
- www.mpiz-Kolen.mpg.de.
- [www.Science Direct](http://www.ScienceDirect).
- [www.Scientia Agricolo](http://www.ScientiaAgricola).
- [www.wiley interscience](http://www.wileyinterscience)

PLANT BIOTECHNOLOGY

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	BT 511*	PRINCIPLES OF BIOTECHNOLOGY	3(2+1)
2.	BT 512*	MOLECULAR CELL BIOLOGY	3(3+0)
3	BT 513*	TECHNIQUES IN MOL BIOL I	3(0+3)
II-Semester			
4	BT 521*	FUNDAMENTALS OF MOLECULAR BIOLOGY	3(3+0)
5.	BT 522	PRINCIPLES OF GENETICS	3(2+1)
6.	BT 523	TECHNIQUES IN MOL BIOL II	3(0+3)
7.	BT 524	NANO-BIOTECHNOLOGY	3(3+0)
8.	BT 525	MICROBIAL/INDUSTRIAL BIOTECHNOLOGY	3(2+1)
9.	BT 526	INTRODUCTION TO BIOINFORMATICS	3(2+1)
10.	BT 527	ANIMAL BIOTECHNOLOGY	3(3+0)
III-Semester			
11.	BT 531	PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION	3(1+2)
12.	BT 532	BIODIVERSITY, BIOSAFETY, IPR AND BIOETHICS	3(3+0)
13.	BT 533	BIOINFORMATICS, GENOMICS AND PROTEOMICS	3(2+1)
14.	BT 534	ENVIRONMENTAL BIOTECHNOLOGY	3(3+0)
15	BT 535	IMMUNOLOGY AND MOLECULAR DIAGNOSTICS	3(2+1)
16	BT 536	MOLECULAR BREEDING	3(3+0)
IV-Semester			
17	BT 541	SEMINAR	1
18.	BT 542	COMPREHENSIVE	2
19.	BT 543	RESEARCH	15
Ph.D.			
I-Semester			
1.	BT 611*	ADVANCES IN PLANT MOLECULAR BIOLOGY	3(3+0)
2	BT 612*	ADVANCES IN GENETIC ENGINEERING	3(3+0)
3	BT 613	ADVANCES IN MICROBIAL BIOTECHNOLOGY	3(3+0)
II-Semester			
4.	BT 621	ADVANCES IN CROP BIOTECHNOLOGY	3(2+1)
5	BT 622	ADVANCES IN FUNCTIONAL GENOMICS AND PROTEOMICS	3(2+1)
6	BT 623	COMMERCIAL PLANT TISSUE CULTURE	3(3+0)
7	BT-624	ADVANCES IN ANIMAL BIOTECHNOLOGY	3(3+0)
III and onward Semesters			
8	BT 641	SEMINAR	2
9	BT 642	PRELIMINARY	4
10	BT 643	RESEARCH	40

*Core courses

PLANT BIOTECHNOLOGY

M.Sc. (Ag) Programme

BT 511

Principles of Biotechnology

3 (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 and function.

UNIT II

DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; Gene libraries; PCR amplification; Plant and animal cell, 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

Isolation of genomic and plasmid DNA. Gel electrophoresis techniques. Restriction enzyme digestion, ligation, theoretical demonstration of transformation and screening of transformants. PCR and molecular marker analysis. 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 – a Laboratory Manual. 2nd Ed. Cold Spring Harbour Laboratory Press.

Singh BD. 2007. Biotechnology Expanding Horiozon. Kalyani Publishers.

BT 512

Molecular Cell Biology

3(3+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

Organelle 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 P.K. 2003. Cell and Molecular Biology. 2nd Ed. Rastogi Publ.

Lodish H. 2003. Molecular Cell Biology. 5th Ed. W.H. Freeman & Co.

Primrose S.B. 2001. Molecular Biotechnology. Panima.

BT 513

Techniques in Molecular Biology I

3(0+3)

Objective

To provide hands on training on basic molecular biology techniques.

Theory

UNIT I

Purification of proteins by different methods, theory of extraction procedures, centrifugation principles, salting-out, salting-in, dialysis, gel filtration, ion-exchange chromatography, electrophoresis, molecular weight determination, western-blotting

UNIT II- Introduction to molecular markers such as RAPD, RFLP, SSR. Dot blot analysis; Southern hybridization; Northern hybridization; Western blotting

Practical

UNIT I

Good lab practices; Biochemical techniques: Preparation of buffers and reagents. Gel electrophoresis- agarose and PAGE (nucleic acids and proteins);

UNIT II

Growth of bacterial culture and preparation of growth curve; Isolation of plasmid DNA from bacteria; Restriction digestion of plasmid DNA; Isolation plant DNA and its purity analysis.

UNIT III

Gene cloning – genetic transformation and selection of transformants; PCR and optimization of factors affecting PCR and RAPD analysis

Suggested Readings

Ausubel F.M, Brent R, Kingston R.E, Moore D.D, Seidman J.G, Smith J.A & Struhl K. 2002. Short Protocols in Molecular Biology. John Wiley.

Kun L.Y. 2006. Microbial Biotechnology. World Scientific.

Sambrook J, Russell D.W & Maniatis T. 2001. Molecular Cloning: a Laboratory Manual. Cold Spring Harbour Laboratory Press.

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 I.X. Peterson Publications/ Panima.

Malacinski G.M & Freifelder D. 1998. Essentials of Molecular Biology. 3rd Ed. Jones & Bartlett Publishers.

Nelson D.L & Cox M.M.2007. Lehninger's Principles of Biochemistry. W.H. Freeman & Co.

Primrose S.B. 2001. Molecular Biotechnology. Panima.

Watson J.D, Bakee T.A, Bell S.P, Gann A, Levine M & Losick R. 2008. Molecular Biology of the Gene. 6th Ed. Pearson Education International.

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**

Early concepts of inheritance; Discussion on Mendel's paper; Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage, recombination and genetic mapping in eukaryotes, Somatic cell genetics.

UNIT II

Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes; Mutations and mutagenic agents.

UNIT III

Genetic code and protein biosynthesis; Gene regulation, Genes in development; Extra chromosomal inheritance, Male sterility and incompatibility; Recombination in bacteria, fungi and viruses, tetrad analysis.

UNIT IV

Inheritance of quantitative traits; Concepts in population genetics; Genes and behavior; Genetics and evolution; Recombinant DNA technology; Genetic fine structure analysis, Split

genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families; An overview of some recent discoveries in the field of genetics.

Practical

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. Pedigree analysis in humans. Numerical problems on Hardy Weinberg Equilibrium, Quantitative inheritance and Molecular genetics.

Suggested Readings

Klug W.S & Cummings M.R. 2003 Concepts of Genetics. Peterson Education.

Lewin B. 2008. Genes I.X. Jones & Bartlett Publ.

Russell P.J. 1998. Genetics. The Benjamin/Cummings Publ. Co.

Strickberger M.W.1990. Genetics. Collier MacMillan.

Tamarin R.H. 1999. Principles of Genetics. Wm. C. Brown Publs.

Uppal S, Yadav R, Subhadra & Saharan R.P. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

BT 523

Techniques in Molecular Biology-II

3(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 RTPCR analysis; 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 F.M, Brent R, Kingston R.E, Moore D.D, Seidman J.G, Smith J.A & Struhl K. 2002. *Short Protocols in Molecular Biology*. Wiley.

Caldwell G, Williams S.N & Caldwell K. 2006. *Integrated Genomics: A Discovery-Based Laboratory Course*. John Wiley.

Sambrook J, Russel D.W & Maniatis T. 2001. *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbour Laboratory Press.

BT 524

Nano-Biotechnology

3(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; Nanoparticulate 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.

BT 525

Microbial/ Industrial Biotechnology

3(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 and their 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

Isolation of industrially important microorganisms, their maintenance and improvement.

Production of industrial compounds such as alcohol/citric acid/ lactic acid and their recovery. Study of bio-reactors and their operations. Production of biofertilizers. Experiments on microbial fermentation process, harvesting purification and recovery of end products.

Suggested Readings

Huffnagle G.B & Wernick S. 2007. The Probiotics Revolution: The Definitive Guide to Safe, Natural Health. Bantam Books.

Kun L.Y. 2006. Microbial Biotechnology. World Scientific.

Primrose S.B. 2001. Molecular Biotechnology. Panima.

BT 526

Introduction to Bioinformatics

3(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, genbank, 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 aided drug design – basic principles, docking, QSAR.

UNIT IV

Analysis packages – commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical

Usage of NCBI resources. Retrieval of sequence/structure from databases. Visualization of structures. Docking of ligand receptors. 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.

BT 527

Animal Biotechnology

3(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-splitting, 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 19 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. *New Generation 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.

BT 531

Plant Tissue Culture and Genetic Transformation

3(2+1)

Objective

To familiarize the students and provide hands on training on various techniques of plant tissue culture, genetic engineering and transformation.

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

Methods of plant transformation; Vectors for plant transformation; Genetic and molecular analyses of transgenics; Target traits and transgenic crops; Biosafety issues, testing of transgenics, regulatory procedures for commercial approval.

Practical

Laboratory set-up. Preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration. Anther and pollen culture. Embryo rescue. Suspension cultures and production of selected secondary metabolites. Gene transfer using different methods, reporter gene expression, selection of transformed tissues/plants, molecular analysis.

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 Tissue Culture. 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 Horizon. Kalyani.

BT 532

Biodiversity, Biosafety, IPR and Bioethics

3(3+0)

Objective

To discuss about various aspects of biosafety regulations, IPR and bioethic concerns arising from the commercialization of biotech products.

Theory

UNIT I

Definition, History and Geographical causes for diversity, Genetic diversity, Molecular Diversity, Species and population biodiversity, Quantifying biodiversity, Maintenance of ecological biodiversity, biodiversity and centers of origin of plants, Biodiversity and hot spots in India, Collection and conservation of biodiversity, assessing, analyzing and documenting Biodiversity. Morphological and Molecular characterization of Biodiversity,

UNIT II

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 III

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 IV

Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and non-radio 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

BT 533

Bioinformatics, Genomics and Proteomics

3(2+1)

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; Proteome analysis, etc.

UNIT IV

General uses and application of Crystallography. Enzymes engineering, design and construction of novel enzymes

UNIT V

Applications of genomics and proteomics in agriculture, human health and industry.

Practical

- i. Retrieval of sequence/structure from databases
- ii. Visualization of structures
- iii. Docking of ligand receptors
- iv. BLAST exercises.

v. Other softwares used in Bioinformatics

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.

BT 534

Environmental Biotechnology

3(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, filtration, 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 micro-organisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management of environmental problems.

Suggested Readings

- Evans GM & Furlong JC. 2002. Environmental Biotechnology: Theory and Application. Wiley International.
- Jordening H-J & Winter J. 2006. Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

BT 535

Immunology and Molecular Diagnostics

3(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; Immune-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

Preparation of buffers and reagents. Immunoblotting, immunoelectrophoresis and fluorescent antibody test. Enzyme immunoassays including ELISA western blotting. Extraction and identification of DNA/RNA of pathogenic organisms.

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. New Generation 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.

BT 536**Molecular Breeding****3(3+0)****Objective**

To familiarize the students about the use of molecular biology tools in plant breeding.

Theory**UNIT I**

Model Genetic System-lamda, E.coli, neurospora, yeast, Drosophilla, Arabidopsis and maize, principles of inheritance, qualitative and quantitative traits, DNA as genetic material, sources of genetic variation,

UNIT II

Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Aspects of molecular breeding.

UNIT III

Development of sequence based molecular markers – SSRs and SNPs; Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits.

UNIT IV

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 V

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. 16

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.

Ph.D Programme

BT 611

Advances in Plant Molecular Biology

3(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 gene expression, 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*. 3rdEd. 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.

BT 612

Advances in Genetic Engineering

3(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.

UNIT V

Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ T-DNA insertion lines; homologous recombination; microarray profiling

Suggested Readings

Christou P & Klee H. 2004. Handbook of Plant Biotechnology. John Wiley & Sons.

BT 613

Advances in Microbial Biotechnology

3(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

BT 621

Advances in Crop Biotechnology

3(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.

BT 622 ADVANCES IN FUNCTIONAL GENOMICS AND PROTEOMICS 3(3+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; microarrayprofiling; 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

BT 623

Commercial Plant Tissue Culture

3(2+1)

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.

Practical

Laboratory set-up, preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration. Case studies of commercial plant regeneration system of important aromatic/ medicinal plants.

Suggested Readings- Specific journals and published references

BT 624

Advances in Animal Biotechnology

3(3+0)

Objective

Intended to provide cutting edge knowledge on advances in different areas of 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

Specific journals and published references.

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. <http://www.cato.com/biotech/>
- ☐ The Transgenic/Targeted Mutation Database (TBASE)
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

BIOCHEMISTRY

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	BIOCH-511*	Basic Biochemistry	3(2+1)
2.	BIOCH-512*	Techniques in Biochemistry	3 (2+1)
3	BIOCH-513*	Intermediary Metabolism-I	3 (3+0)
II-Semester			
4	BIOCH-521	Plant Biochemistry	3 (2+1)
5.	BIOCH-522*	Intermediary metabolism-II	3 (3+0)
6.	BIOCH-523	Enzymology	3 (2+1)
7.	BIOCH-524	Molecular Biology	3 (3+0)
III-Semester			
8.	BIOCH-531	Biochemistry of Biotic and Abiotic Stresses in Plants	3 (3+0)
9..	BIOCH-532	Recombinant DNA Technology	3 (2+1)
10.	BIOCH-533	Food and Nutritional Biochemistry	3 (2+1)
IV-Semester			
11	BIOCH 541	SEMINAR	1
12.	BIOCH 542	COMPREHENSIVE	2
13.	BIOCH 543	RESEARCH	15

	SUPPORTING COURSE(S)		
1	STAT-511	STATISTICAL METHODS	3 (2+1)
2	PBG-511	PRINCIPLES OF GENETICS & CELL BIOLOGY	3(2+1)
3	PPATH-513	PRINCIPLES OF PLANT PATHOLOGY	3(3+0)
4	PBG-523	BIOTECHNOLOGY FOR CROP IMPROVEMENT	3(2+1)
5	P PHYS-532 [#]	PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS-CARBON AND NITROGEN ASSIMILATION	3 (2+1)

***Core courses**

BIOCHEMISTRY

M.Sc.(Ag) Programme

BIOCH-511

Basic Biochemistry

3 (2+1)

Objective

To provide elementary knowledge of structure, functions and metabolism of biomolecules

Catalogue description

Introduction, chemistry of major bio-molecules-classification, chemical structure, properties, functions. Chemical structure of vitamins, hormones, secondary metabolites- porphyrins, phenolics terpenes, anthocyanins.

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.

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. Hormones – animal, plants and insects.

UNIT IV

Metabolism of carbohydrates, lipids, proteins. Oxidative phosphorylation. DNA replication, transcription and translation. Recombinant DNA technology

Practical

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids, Estimation of Proteins by Lowry's method, Estimation of DNA and RNA by diphenylamine and orcinol methods, Estimation of Ascorbic acid, Separation of biomolecules by TLC and Paper chromatography.

Suggested Readings

Conn EE & Stumpf PK. 1999. Outlines of Biochemistry. John Wiley.

Metzler DE. 2006. Biochemistry. Vols. I, II. Wiley International.

Nelson DL & Cox MM. 2007. Lehninger Principles of Biochemistry. 5th Ed. MacMillan.

Voet D, Voet J G & Pratt CW. 2007. Fundamentals of Biochemistry. John Wiley.

BIOCH-512

Techniques in Biochemistry

3(2+1)

Objective

To impart practical knowledge about various techniques used in purification and characterization and estimation of cellular constituents.

Catalogue Description

Theoretical and Practical knowledge of various separation, quantification and characterization techniques of biomolecules. Purification and characterization of protein

Theory

UNIT I

Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & column chromatography, HPTLC, Gas-liquid chromatography, HPLC and FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel electrophoresis (PAGE) – native, SDS-PAGE, 2D-PAGE, and capillary electrophoresis.

UNIT II

Spectrophotometry: Principles and applications UV-Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy. circular dichromism and optical rotatory dispersion, fundamentals, application and experimental techniques polarization,

UNIT III

Hydrodynamic methods of separation of biomolecules such as viscosity and sedimentation-their principles, variants and applications. Preparative, density gradient and ultracentrifugation. Analysis of sub-cellular fraction.

UNIT IV

Tracer techniques in biology: Concept of radioactivity, radioactivity counting methods. Concept of α , β and γ emitters, scintillation counters, γ -ray spectrometers, autoradiography, applications of radioactive tracers in biology, principles and applications of phosphor imager.

Practical

Estimation of biomolecule using spectrophotometer, Separation of carbohydrates and amino acids by paper chromatography, Separation of lipids by thin layer chromatography. Separation of proteins by gel filtration and Electrophoresis. Analysis of fatty acids by GLC. Analysis of steroids by HPLC.s

Suggested Readings

Clark JM. 1977. *Experimental Biochemistry*. 2nd Ed. WH Freeman.

Sawhney SK & Singh R. 2000. *Introductory Practical Biochemistry*. 2nd Ed. Narosa.

Willard M, Merritt LL & Dean JA. 1981. *Instrumental Methods of Analysis*. 4th Ed. Van Nostrand.

William BL & Wilson K. 1975. *Principles and Techniques of Practical Biochemistry*. Edward Arnold.

Wilson K, Walker J & Walker JM. 2005. *Principles and Techniques of Practical Biochemistry*. Cambridge Univ. Press.

BIOCH-513

Intermediary metabolism- I

3(3+0)

Objective

To impart knowledge of metabolic pathways of carbohydrates and lipids and their regulation.

Catalogue Description

Metabolic pathways of carbohydrate and lipids and their regulation. Phosphorylation, electron transport chain, bioenergetics. Photosynthesis and metabolic engineering.

Theory

UNIT I

Introduction to metabolism, methods of studying metabolism, metabolic transport mechanism, bioenergetics, biological oxidation, signal transduction- endocrine, exocrine and synaptic signaling molecules, surface and intracellular receptors, G protein and secondary messengers, cAMP, Ca^{++} and calmodulin

UNIT II

Carbohydrate metabolism. Glycolysis- reaction sequences and regulation, metabolism of other hexoses, glycogen- breakdown, and control, glucuronate pathway, Kerb's cycle, anaplerotic and amphipathic nature of Kerb's cycle, glyoxylate pathway, HMP pathway, Entner-Duoderoff pathway, Biosynthesis of carbohydrates- gluconeogenesis, glycogen biosynthesis, phosphorylation, electron transport chain and ATP synthase system

UNIT III

Lipids metabolism: saturated and unsaturated Fatty Acid degradation., acylglycerols, phosphoglycerides and sphingolipids such as sphingomyelin, cerebrosides and gangliosides, ketone bodies synthesis and degradation, fatty acid biosynthesis, acetyl CoA carboxylase, fatty acid synthetases, biosynthesis of unsaturated fatty acids, biosynthesis of triacylglycerol, phosphoglycerol and sphingolipids, biosynthesis of steroids. terpenes and eicosanoids.

UNIT IV

Carbohydrate and lipid metabolism regulations and disorders, carbohydrate and lipid metabolic profiles of major organs, Metabolic engineering concepts.

Suggested Readings

Berg JM, Tymoczko JL, Stryer L & Clarke ND 2000. *Biochemistry*. 5th Ed. WH Freeman & Co.

Metzler DE. 2006. *Biochemistry*. Vols. I, II. John Wiley.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

Zubey GL. 1998. *Biochemistry*. 4th Ed. WCB London.

BIOCH-521

Plant Biochemistry

3 (2+1)

Objective

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

Catalogue Description

Scope and importance of biochemistry in Agriculture. Photosynthesis, photorespiration. Nitrogen fixation, seed germination, fruit ripening and secondary metabolites. Phytohormones and their mode of action.

Theory

UNIT I

Scope and importance of biochemistry in Agriculture, Plant cell organelles and their separation, structure and function. Photosynthetic pigments, 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 into 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

Estimation of chlorophyll, protein by Lowry's method and starch. Estimation of nitrate content by hydrazine sulphate reduction method. *In vivo* assay of nitrate reductase activity, Assay of nitrogenase activity by acetylene reduction method.

Suggested Readings

Buchanan BB, Gruissem W & Jones RL. 2000. *Biochemistry and Molecular 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.

BIOCH-522

Intermediary metabolism –II

3(3+0)

Objective

To impart knowledge of metabolic pathways of amino acids, proteins and nucleic acids in respect to their regulation.

Catalogue Description

Metabolic pathways of proteins and nucleic acid in respect of their reaction sequences, regulatory points, mode of regulation. Metabolism of xenobiotics and inborn errors of metabolism

Theory

UNIT I

Nitrogen cycle, nitrification and denitrification process with characteristics of organisms capable of these processes, biological nitrogen fixation- nitrogen fixing organisms(symbionts and nonsymbionts), characteristics features of nitrogenase, its mechanism and nitrogen fixation regulation by *nif* gene expression,

UNIT II

General reactions of amino acid metabolism- Mechanisms of transamination, decarboxylation, deamination and racemization etc., Pyridoxal phosphate- structure and its role in general amino acid metabolism with reaction mechanism, assimilation of amino acids, ammonia excretion, urea cycle and their regulation.

UNIT III

Degradation and biosynthetic pathways of protein amino acids operating in animals, plants and microbes and their regulation, Porphyrine metabolism, Biosynthesis of biogenic amines e.g. histamine, serotonin, melatonin, GABA shunt, Metabolism of xenobiotic and detoxification mechanism

UNIT IV

Degradation of pyrimidines, purines and their nucleotides, biosynthesis of pyrimidines and purines by *de novo* and salvage pathways, Synthesis of thymidine, deoxyribose and deoxyribonucleotides and metabolism of nucleotide coenzymes, regulation of purine and pyrimidines metabolisms, inborn errors of metabolism, integration of metabolism.

Suggested Readings

Berg JM, Tymoczko JL, Stryer L & Clarke ND 2000. *Biochemistry*. 5th Ed. WH Freeman & Co.

Metzler DE. 2006. *Biochemistry*. Vols. I, II. John Wiley.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

Zubey GL. 1998. *Biochemistry*. 4th Ed. WCB London.

BIOCH-523

Enzymology

3(2+1)

Objective

To impart knowledge about the catalytic role of enzymes, their structure, physico-chemical, kinetic and regulatory properties and mechanism of action.

Catalogue description

Historical perspectives, classification and nomenclature of enzymes. Enzyme kinetics and inhibitors. Factors affecting activity.

Theory

UNIT I

Introduction and historic perspective, Enzyme nomenclature and classification, enzyme compartmentalization in cell organelles, measurement of enzyme activity. ribozymes, isozymes, abzymes.

UNIT II

Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. cofactors, coenzymes- their structure and role.

UNIT III

Enzyme kinetics, enzyme inhibition and activation, multienzyme complexes, allosteric enzymes and their kinetics, regulation of enzyme activity.

UNIT IV

Isolation and purification of enzymes, Applications of enzymes in chemical and food industry, enzyme immobilization, biosensors and clinical applications of enzymes.

Practical

Enzyme assay of alpha-amylase. Isolation and purification of acid phosphatase. Effect of substrate concentrations on enzyme activity- alpha-amylase or acid phosphatase. Determination of pH and temperature optima of peroxidase. Determination of the pH and temperature optima of nitrate reductase.

Suggested Readings

Bergmeyer HU. 1983. Methods of Enzymatic Analysis. Vol. II. Verlag Chemie, Academic Press.

Dixon M, Webb EC, Thorne CJR & Tipton KF. 1979. Enzymes. 3rd Ed. Longman.

Maragoni AG. 2003. Enzyme Kinetics - A Modern Approach. John Wiley.

Palmer T. 2001. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry. 5th Ed. Horwood Publ.

Price NC & Stevens L. 2003. Fundamentals of Enzymology. Oxford Univ. Press.

Wilson K & Walker J. (Eds.). 2000. Principles and Techniques of Practical Biochemistry. 5th Ed. Cambridge Univ. Press.

BIOCH-524

Molecular Biology

3(3+0)

Objective

To provide knowledge regarding genes, their functions, expression, regulation and transfer in heterologous systems.

Catalogue description

Chemistry and structure of nucleic acids. Organization of DNA and replication. Protein synthesis and gene regulation.

Theory

UNIT I

Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, chromatin structure and function.

UNIT II

DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, inhibitors of replication repetitive and non-repetitive DNA, satellite DNA; transcription process, RNA editing, RNA processing.

UNIT III

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthetases, translation and Post translational modification; regulation of gene expression in prokaryotes and eukaryotes, molecular mechanism of mutation.

UNIT IV

Proteomics, Principle and methods of 2D-PAGE, MS, MALI-TOF, Protein microarray, Site directed mutagenesis

Suggested Readings

Adams RLP, Knowler JT & Leader DP. 1992. The Biochemistry of the Nucleic Acids. 11th Ed. Chapman & Hall.

Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD 2006.

Molecular Biology of the Cell. 6th Ed. Garland Publ.

Blackburn GM & Gait MJ. 1996. Nucleic Acids in Chemistry and Biology. 2nd Ed. Oxford University Press.

Freifelder D & Malacinski GM. 1996. Essentials of Molecular Biology. 3rd Ed. Panima.

Glick BR & Pasternak JJ. 1994. Molecular Biology: Principles and Applications of Recombinant DNA Technology. ASM Press.

Lewin B. 2007. Genes IX. Oxford University Press.

Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D & Darnell J. 1999. Molecular Cell Biology. WH Freeman.

Old RW & Primrose SB. 1989. Principles of Gene Manipulation: An Introduction to Genetic Engineering. 4th Ed. Blackwell Scientific Publ.

Sambrook J & Russel DW. 2001. Molecular Cloning: A Laboratory Manual. Vols. I-III. Cold Spring Harbor.

BIOCH-531

Biochemistry of Biotic and Abiotic Stresses

3 (3+0)

Objective

To impart latest development about biochemistry of biotic and abiotic stresses in plants.

Catalogue Description

Biochemical basis of biotic and abiotic stress. Molecular strategies for imparting tolerance against biotic and abiotic stress

Theory

UNIT I

Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

UNIT II

Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance.

UNIT III

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids, pathogen-derived resistance.

UNIT IV

Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

UNIT V

Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes defense system. Role of calcium nitric oxide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

Suggested Readings

Basra AS. 1997. *Stress Induced Gene Expression in Plants*. Harwood Academic Publ.
Chessin M, DeBorde D & Zipf A. 1995. *Antiviral Proteins in Higher Plants*. CRC Press.
Crute IR, Burdon JJ & Holub EB. (Eds.). 1997. *Gene-for-Gene Relationship in Host-Parasite Interactions*. CABI.

BIOCH-532

Recombinant DNA Technology

3(2+1)

Objective

To provide insight into various methods of gene cloning and their application.

Catalogue Description

Gene isolation and cloning methods, PCR, molecular markers and their application. Site directed mutagenesis, gene therapy, bioethics issues and IPR.

Theory

UNIT I

Structure of DNA; Function of genes and genomes; Restriction enzymes and vectors; Methods of gene isolation and cloning. Nucleic acid hybridization; PCR and its applications;

UNIT II

Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genomics and transcriptomics.

UNIT III

Genetic engineering methods and transgenics. Application of genetic engineering in Agriculture, Medicine, Forensics.

UNIT IV

Site directed mutagenesis, gene targeting, gene therapy. Biotechnology; Bio-safety and bioethics issues; Intellectual property rights in recombinant DNA research.

Practical

Isolation and purification of DNA and RNA from different sources, Purity check of isolated DNA and RNA. Restriction fragmentation and separation of DNA by agarose electrophoresis. RAPD analysis of DNA, cDNA synthesis using PCR, Southern and Northern blotting experiments

Suggested Readings

Molecular biology (2005) by David P. Clark.
Molecular biology of the Cell (2008) by Bruce Alberts.
Molecular biology and Biotechnology (2009) by John M. Walker, Ralph Rapley
Biotechnology: Expanding Horizons (2010) by B D Singh.

BIOCH-533

Food and Nutritional Biochemistry

3(2+1)

Objective

To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.

Catalogue Description

Meaning and scope of nutrition, digestion and absorption, Biochemical function of nutrients-macronutrients, vitamins and mineral nutrients, Anti nutritional factors and their biological effects, Indices of Food quality, principles of human nutrition, Malnutrition, Food sensitivity

Theory

UNIT I

Meaning and scope of nutrition, food nutrition, diet, types and classes of nutrients; non-nutrient constituents of diet, dietary fibre, nutrition; Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables. Physico-chemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.). Digestion and absorption, digestive secretions, their characteristic features and control, protection of G.I. tract from digestive secretions, food digestion and absorption, microflora of the G.I. tract;

UNIT II

Biochemical functions of nutrients, macronutrients- carbohydrates, fats and proteins, vitamins, water soluble and fat soluble vitamins, mineral nutrients, nutraceuticals, enzymes and metabolic protein factors, cofactor role, electrolytic function, constituents of skeletal tissues, interrelationship in nutrient functions, mineral deficiency diseases; Antinutritional factors, dietary fibre, toxic, natural constituents, food contaminants and additives;

UNIT III

Indices of food quality, energy and nutritive value of foods, food composition, factors affecting bioavailability of nutrients, biological value of proteins; Principles of human nutrition; concept of a balanced diet, nutritional requirements – RDA, special diets, assessment of nutritional status; Malnutrition, biochemical bases of nutritional diseases, diseases of inadequate and excessive intake, protein energy, malnutrition, nutritional anemia, deficiency diseases of thiamine, vitamin D and iodine, macronutrient imbalance; Food sensitivity: immunologically mediated food sensitivity, nature and properties of antigens in foods, mechanism of induction of allergic reactions, diagnostic tests for food, hypersensitivity, non-immunologically mediated food sensitivity, food sensitivity due to metabolic diseases, gastrointestinal diseases, food additives, pharmacologic agents, food toxins and poisonous and psychological factors.

UNIT IV

Effect of cooking, processing and preservation of different food products on nutrients, biochemical aspects of food spoilage, role of lipase and lipoxygenase, oxidative rancidity and antioxidants. Enzymes in food industry, food additives (coloring agents, preservatives etc.), biogenesis of food flavours and aroma, nutritional quality of plant, dairy, poultry and marine products.

Suggested Readings

- Alais C & Lindel G. 1995. Food Biochemistry. Amazon Springer.
DeMan JM. 1999. Principles of Food Chemistry. 3rd Ed. Springer.
Fennema OR. 1996. Food Chemistry. 3rd Ed. CRC Press.
Hulme AC. (Ed.). 1970. Biochemistry of Fruits and Vegetables and their Products. Vols. I, II. Academic Press.
Ranganna S. (Ed.). 1986. Handbook of Analysis and Quality for Fruits and Vegetable Products. Tata McGraw Hill.
Robinson DS. 1987. Food Biochemistry and Nutritional Value. Longman

List of Journals

- Annual Review of Biochemistry
- Annual Review of Genetics
- Annual Review of Plant Physiology and Plant Molecular Biology
- Biochemical and Biophysical Research Communication
- Biochemical Journal
- Biochim. Biophysic Acta
- Cell
- Current Science
- Federation of European Biochemical Society
- Indian Journal of Experimental Biology
- Journal of Biological Chemistry
- Journal of Immunology
- Journal of Molecular Modeling
- Journal of Plant Biochemistry and Biotechnology
- Nature
- Physiologia Plantarum
- Plant Physiology
- Plant Science
- Planta
- Proceedings of National Academy of Sciences, USA
- Protein Science
- RNA
- Science
- Scientific American
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Plant Sciences

e-Resources

- www.unixl.com/dir/molecular_sciences/biochemistry/biochemistry_jobs/
- www.unixl.com/dir/medical_sciences/
- <http://www.ncbi.nlm.nih.gov/>
- <http://us.expasy.org>
- <http://us.expasy.org/spdbv/>
- <http://www.brenda.uni-koeln.de/>
- <http://www.worthington-biochem.com>
- <http://www.cefotaxime.net>
- <http://home.123india.com/nbsc/>
- <http://www.biochemist.org>
- <http://www.gwu.edu/~mpb>

LIVESTOCK PRODUCTION AND MANAGEMENT

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc(Ag)			
I-Semester			
1.	LPM-511*	CATTLE AND BUFFALO PRODUCTION AND MANAGEMENT	3(2+1)
2.	LPM-512*	SHEEP AND GOAT PRODUCTION AND MANAGEMENT	3(2+1)
3	LPM-513	EQUINE, SWINE AND LABORATORY ANIMAL PRODUCTION AND MANAGEMENT	3(2+1)
II-Semester			
4	LPM-521	SHELTER MANAGEMENT AND CLIMATOLOGY	3(2+1)
5.	LPM-522	PRINCIPLES OF ENVIRONMENTAL HYGIENE AND WASTE MANAGEMENT	3(3+0)
6.	LPM-523 *	POULTRY FARM AND HATCHERY MANAGEMENT	3(2+1)
7.	LPM-524	FARM ANIMAL BEHAVIOUR AND WILD LIFE MANAGEMENT AND CONSERVATION	3(3+0)
III-Semester			
8.	LPM-531*	INTEGRATED LIVESTOCK FARMING SYSTEM	3(2+1)
9..	LPM-532	LIVESTOCK BUSINESS MANAGEMENT	3(2+1)
IV-Semester			
10	LPM 541	SEMINAR	1
11.	LPM 542	COMPREHENSIVE	2
12.	LPM 543	RESEARCH	15

	SUPPORTING COURSES		
1	STAT-511	STATISTICAL METHODS	3 (2+1)
2	AGECON-513	AGRICULTURE PRODUCTION ECONOMICS	3(2+1)
3	AGECON-521	AGRICULTURAL MARKETING AND PRICE ANALYSIS	3(2+1)
4	AGECON-531	AGRICULTURE FINANCE AND PROJECT MANAGEMENT	3(2+1)
5	EXTED-531	RESEARCH METHODS IN BEHAVIOURAL SCIENCES	3(2+1)

LIVESTOCK PRODUCTION AND MANAGEMENT

M.Sc.(Ag) Programme

LPM- 511 Cattle and Buffalo Production and Management 3 (2+1)

Theory

UNIT –I

Introduction-Development of dairy industry in India and world.Present status and future prospectus of livestock development in India

UNIT-II

Important breeds of cattle and buffalo, trait of economic importance and their inter-relationship- selection of high quality animals. Role of management in improving the reproduction efficiency in farm animals. Housing and rearing systems.

UNIT-III

Breeding management. System of breeding. Economic traits Methods of breeding. Prenatal and post natal care and management of cattle and buffalo. Care of neonate and young calves. Management strategies for reducing mortality in calves, age at first calving and calving interval in cattle and buffaloes.

UNIT-IV

Management of labour. Milking management.machine milking and hand milking. Different laws governing the livestock sectors to produce quality products on par with international standards. Technique of harvesting clean and hygienic livestock products. Transportation of animals, health management. Wallowing in buffaloes. Management of draught animals and summer management.

UNIT-V

Feed and fodder resources used for feeding of cattle and buffaloes. Scientific technique of feeding,watering. Computation of practical and economical ration, supply of green fodder around the year and enrichment of poor quality roughages.

Practical

Visit to cattle farms and critical analysis of various types of managerial practices. Study of breeding management in the farm. Analysis of practical feeding management. Disease control, housing, milking, calf, heifer and adult management. Dairy cattle and buffalo judging. Project preparation for external funding of commercial farms and enterprises for dairy products. Marketing strategies for milk, milk products and meat.

Suggested Readings

Arora SP.1997. Feeding of Dairy Cattle and Buffaloes. Kalyani.

Datta G.1994 Care and Management of Dairy Cattle and Buffaloes. 3rd Ed. ICAR

Thomas CK and Sastry,NSR.1991. Dairy Bovine Production. Kalyani.

Watson. 2012.Farm Animals and Their Management. Techno Books & Periodicals

LPM-512 Sheep and Goat Production and Management 3(2+1)

Theory

Unit-I

Introduction. Population structure and importance. Advantages and disadvantages of sheep farming under different systems of management. Type of housing and equipments. Important sheep and goat breeds. Advantages and disadvantages of sheep and goat farming.

UNIT-II

Breeding management: Breeding seasons, fitness of purchase for first breeding. Methods of detection of heat. Natural service and artificial insemination. Care of pregnant animals. Breeding stock. Use of teaser and culling.

UNIT-III

Feeding management. Feeding methods. Principles to be followed in feeding and watering. Feeder and waterer space. Designing feeders and waterers. Range management. Stocking rate, pasture improvement and utilization. Management under stall fed conditions. Transportation of sheep and goat.

UNIT-IV

Disease management: Role of management in the prevention and control of diseases. Special management: Deworming, dipping spraying and shearing. Avoidance of goatry odour in milk, tugging.

UNIT-V

Wool: importance of wool, fiber structure, fleece characters and goat fibers. Characters of mohair and pashmina, fur and Angora, marketing of goat fiber/wool. Planning of sheep and goat farm of various size. Economic of sheep and goat farming.

Practical

Visit to sheep and goat farms and critical analysis of various managerial practices under different conditions. Study of practical housing management. Analysis of practical disease control management. Record keeping. Preparation of project for commercial farming. Characterisation of sheep and goat, handling of sheep and goat. Daily and periodical operations for sheep and goats. Methods of identification of sheep and goat. Cost of rearing sheep and goat for mutton and wool. Housing plans for various age and categories of sheep and goat. Dipping, vaccination of sheep and goat. Shearing of wool.

Suggested Readings

Devendra C and Mecleroy GB 1982. Goat and Sheep Production in Tropics. Longman

Gupta, J L. 2006 Sheep Production and Management. B S Publication.

ICAR.2008. Hand Book of Animal Husbandry 3rd Ed.ICAR

Kaushish 1994. Sheep Production in the Tropics and Subtropics. Scientific publication.

Jindal. S. K.2012.Goat Production and Health Management.New India Pub Agency.

LPM-513 Equine, Swine and Laboratory Animal Production and Management 3(2+1)

Theory

UNIT-I

Introduction. Population and importance. Economic contribution of pigs and equine. Advantages and disadvantage of swine and equine keeping. Systems of management. Problems in equine and pig farming.

UNIT-II

Breeds of swine and equine. Selection of breeding stocks. Breeding season. Age and weight at first services. Methods of detection of heat. Natural service and AI. Care of pregnant animals, young ones and growing stock. Care of breeding males.

UNIT-III

Sanitation and hygiene, disease prevention measures. Housing and equipments. Wallowing. Role of management in the prevention and the control of diseases.

UNIT-IV

Feeding and management of new born, weaner, finishers, dry, pregnant and farrowing and foaling. Feeding principles to be followed. Methods of watering. Feeder and waterer space. Record keeping.

UNIT –V

Importance of rabbit for meat and fur production. Common breeds of rabbit, rat, mice and guinea pig. Breeding, feeding and management of laboratory animals. System of housing. Common diseases and their control measure. Marketing of meat and fur.

Practical

Visits to pig, stud and laboratory animal farms. Critical analysis of various types of managerial practices. Analysis of practical breeding management methods and disease control management of pig, equine and laboratory animals. Aging and identification, Judging. Practical care and management at parturition. Economics of production. Project preparation for research and commercial farms.

Suggested Readings

Boden, S. 1995. Swine Practices. W B London.

Narayankhedkar, SG. 1997. Production and Management of Swine, Camel, Equine and Yak. Tindall Pub.

Ronald N and Penman S. 1991. A Manual for Small Scale Rabbit Production. South Asia Publication.

Dimri, U, Sharma, M C and Tiwari R. 2013. Swine Production and Health Management. New India Pub Agency.

Reddy, D V 2007. Applied Nutrition (Livestock, Poultry, Human, Pet, Rabbit and Laboratory animals) IBH, Oxford.

Rajeshwari, YB. 2009. Handbook on Care and Management of Laboratory and Pet Animals. New India Pub Agency.

LPM-521

Shelter Management and Climatology

3(2+1)

Theory

UNIT-I

General principles in planning animal houses. Farmstead and animal houses. Selection of site and planning, layouts for livestock farm of different sizes in different climatic zones in India. Farm structures. General principles of construction of enclosures, floor and road.

UNIT-II

Housing requirements of different classes of Livestock. Preparation of layouts, plans, arrangement of alleys. Fitting and facilities in the houses for dairy cattle, calves, bulls, bullocks, sheep, goat and poultry.

UNIT-III

Improvement of existing buildings, water supply, feed and fodder delivery systems. Economics of livestock housing.

UNIT-IV

Housing. Disease control measures and sanitation of all classes of livestock.

UNIT-V

Definition of climate. Classification of climatic regions. Climatic factors. Assessment of climate. Study of climatic factors in relation to animal production. Estimation of microclimatic conditions in animal house. Measurement of temperature, relative humidity, air velocity and mean temperature of the surrounding, measurement of intensity of light in animal houses. Construction of climographs and hythergraphs. Estimation of cooling power of atmosphere, heat tolerance test in bovines. Microclimate modification in animal house. Importance of light in animal production.

Practical.

Score card for animal houses. Time and motion study in animal houses. Preparation of plans for animal houses for cattle, sheep, pigs, goats and other livestock. Economics of livestock housing. Preparation of plan for animal houses of different sizes and climatic zones of India.

Suggested Readings

Sastry N S R and Thomas, C K 2006. Livestock Production and Management. Kalyani

Thomas, C K and Sastry, NSR 1991. Dairy Bovine Production. Kalyani.

Wathes, C M and Charles, D R 1994. Livestock Housing. CABI.

Lal, D S 1998. Climatology. Sharda Pustak Bhawan, Allahabad.

McDowell, R E. 1972. Improvement of Livestock Production in Warm Climates. W H Freeman.

Siddhartha K and Roger, B 1996. Atmosphere, Weather and Climate. ELBS.

LPM-522 Principles of Environmental Hygiene and Waste Management 3(3+0)**Theory****UNIT-I**

Animal air hygiene. Definition. Composition of air. Air pollution. Factors affecting outdoor and indoor pollution. Effect of assessment of these factors on animal health and production. Methods to control these factors.

UNIT-II

Water hygiene. Importance of water. Impurities and inclusions. Sterilization. Examination of water and water supplies. Collection of samples. Topographical, physical, chemical, bacteriological and microscopic examination of water. Hygienic requirements and standards for drinking water. Quantity of water required by domestic animals. Methods of watering.

UNIT-III

Manure. Quantity of manure voided by domestic animals. Animal excreta a factor in spread of disease. Hygienic and economic disposal of farm waste. Modern techniques used in automation/semi-automation in disposal of farm waste.

UNIT-IV

Environmental protection act. Air (Prevention and control of pollution) act and water (Prevention and control of pollution) act. Biosecurity measures to be adapted for efficient and healthy production.

UNIT-V

Effect of environmental pollution on livestock and its products directly and indirectly. Controlling environmental pollution. Different factors affecting the quality of livestock and its products meant for human consumption.

Suggested Readings

Baba, MD 2007. Environmental Changes and Natural Disaster. New India Pub.

Overcash, M R 1983. Livestock Waste Management. CRC Press.

Thapliyal, D C and Mishra, D S. 1996. Fundamental of Animal Hygiene and Epidemiology. International Book Dist. Co.

Theory**UNIT-I**

Poultry housing system. Cage Vs floor system. Litter management and lights for poultry, rearing turkey, duck and quails.

UNIT-II

Management of chicks, growing, laying and breeding flocks, broiler production, selection and culling of laying flocks.

UNIT-III

Procuring, care and preincubation storage of hatching eggs. Methods of incubation, sanitation disinfection and management of hatchery.

UNIT-IV

Embryonic development and factors affecting fertility and hatchability of eggs.

UNIT-V

Chick sexing, packing and hatchery business. Transporting management of farm and hatchery products and waste.

Practical

Poultry farm management. Brooding of chicks, selection of laying flocks. Disease preventive measures. Selection and care of hatching eggs, incubator operation, fumigation, candling, setting and hatching. Packaging of chicks. Waste management. Marketing of products.

Suggested Readings

Ensminger, ME. 1992. Poultry Science. International Book Dist Co.

Hued, L M. 2003. Modern Poultry Farming. Greenworld.

Powell-Owen, W. 2008. Poultry Farming and Keeping. Daya Books.

Prashad J. 2005. Poultry Production and Management. Kalyani.

Singh, R A. 1996. Poultry Production 3rd Ed Kalyani.

Nandi, S. 2012. Poultry Diseases. : At a Glance. Vardhman Books & Periodicals

LPM-524 Farm Animal Behaviour and Wild Life Management and Conservation**3(3+0)****Theory****UNIT-I**

Introduction to animal behaviour Importance of animal behavior studies. pattern of behavior. Daily and seasonal cycles of behavior. Physiological basis of behavior.

UNIT-II

Environmental modification of behavior. Developmental changes in behavior. Genetic differences in behavior. Behavioural disorders.

UNIT-III

Group formation. Social relationship, process of socialization, locality and behavior. Practical application. Behavioural character for managerial practice. Favourable and unfavourable behavior for domestication. Behavioural adaptations under domestication.

UNIT-IV

Physical environment and behavior. Common vices and their remedial measures. Analysis of behavior in relation to location. Analysis of behavior in relation to climatic environment. Analysis of social behavior.

UNIT-V

Principles and concept . Ecology of wildlife sanctuaries and national parks. Biological and ecological basis of management of wild animals. Wild life protection act. Record keeping. Breeding season pregnancies, parturition, lactation in wild life animals.

Suggested Readings

Arora MP.1995. Animal Behaviour. WB London.
Fraser A F and Broom D M 1997. Farm Animal Behavior and Welfare. CABI.
Kumar,V.1996. Animal Behaviour. WB London
Bobbins C T 1983. Wildlife Feeding and Nutrition. Daya Pub. House
Giles, RH.1978. Wildlife Management. Wild Life Society.
Giles,RH.1984. Wildlife Management Techniques 3rd Ed. Wild Life Society.
WWF.1994 Wild Life Protection Act 1972.(as amended upto 1991) Natraj Pub.
Jadhav,N V,Baig, M I and Devangare,A A 2004. Handbook of Wild Animals and Livestock Management.

LPM-531

Integrated Livestock Farming System

3(2+1)

Theory

UNIT-I

Scope and limitation of integrated farming systems. Sustainability of integrated Livestock Farming Systems and their economic importance.

UNIT-II

Integration of fish,arable farming and different livestock enterprises vis-à-vis gober gas plant. FYM, solar and wind energy utilization,cattle, buffalo,sheep,goat,pig,poultry,rabbit,silk worm and beekeeping etc.

UNIT-III

New approach for changing farming systems in present energy crisis.

UNIT-IV

Project formulation and evaluation of various livestock enterprises.

Practical

Various livestock farming units and their economic analysis. Evaluation of different farming systems and their economic importance. Preparing feasibility report for various farming projects.

Suggested Readings

Mukherjee T K .1992. Integrated Livestock Fish Production Systems
Raman K V and Balaguru. T(Eds)1992. Farming systems research in India: Strategies for Implementation. NAARM
Renard, C(Ed.)1997. Crop Residues in Sustainable Mixed Crop/Livestock Farming system.CABI.
Speirs M and Opsen,O. 1992. Indigenous Integrated Farming System in the Sahel. World Bank.

LPM-532

Livestock Business Management

3(2+1)

Theory

UNIT-I

Management principles. Planning, techniques, strategic planning, organization structure, co-ordination and controlling techniques. Approaches to management.

UNIT-II

SWOT analysis, financial accounting. Accounting records. Balance sheet. Fund Flow statement. Cost and analysis for managerial decisions. Budgeting and control.

UNIT-III

Tools of financial analysis. Working capital financing. Long term financial management. Investment analysis. Capital markets. Corporate risk management. Venture capital.

UNIT-IV

Marketing. Objective strategies. Selecting managing marketing channels. Pricing strategies. Sales promotion. Legislation relating licensing. Company laws.

Practical

Preparation of financial statements, depreciation accounting methods trend and variance analysis, cost volume profit analysis. Financial planning and forecasting. Estimation of working capital requirement. Break even analysis. Visit to livestock business firms and banks. Preparing projects for financing.

Suggested Readings

Koontz H and O'Donnel, C.1999. Essentials of Management. Tata McGraw Hill.

Totler P.2000 Marketing Management. Analysis, Planning and Control. Prentice Hall of India.

Maheshwari, SN.1998. Management Accounting. Tata McGraw Hill

Massie, J L 1995. Essential of Management. Prentice Hall of India

Gangadhar, K S.2009. Livestock Economics, Marketing Business Management and Accountancy. New India Pub Agency

Bardhan.2012. Textbook on Livestock Economics Marketing and Business Management. Techno Books & Periodicals

List of Journal

Asian Journal of Buffalo Production and Management
Australian Journal of Animal Science
British Poultry Science
Canadian Journal of Animal Science
Indian Dairyman
Indian Journal of Animal Nutrition
Indian Journal of Animal Production and Management
Indian Journal of Animal Science
Indian Journal of Dairy Science
Indian Journal of Poultry Science
Indian Journal of Field Veterinarians Science
Internal Journal of Animal Science
Journal of Animal Science
Journal of Dairy Science
Livestock Production Science
Poultry Science
The Indian Veterinary Journal
World Poultry Science Journal

e- Resources

www.pork.org
www.ilri.org
www.fao.org
www.defra.org.uk
www.aciar.gov.au
www.asap.asn.au
www.thepigsite.com
www.epa.com
<http://animalscience.ucdavis.edu>
www.tanu.edu
www.sciencedirect.com
<http://trop.edmgr.com>
www.nianp.res.in
<http://www.aphca.org>
<http://www.ars.usda.gov>

NON CREDIT COURSES

S.No	Course No.	Title	Credit Hrs.
1.	PGS 501	LIBRARY AND INFORMATION SERVICES	1(0+1)
2.	PGS 502	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	1(0+1)
3.	PGS 503 (e- Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1(0+1)
4.	PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	1(0+1)
5.	PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1(0+1)
6.	PGS 506	DISASTER MANAGEMENT	1(0+1)

NON CREDIT COURSES

PGS 501 Library and Information Services 1(0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information-Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

PGS 502 Technical Writing and Communications Skills 1(0+1)

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review

article.

Communication Skills -Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.

Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.

James HS. 1994. Handbook for Technical Writing. NTC Business Books.

Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. Speaking English Effectively. MacMillan India.

Richard WS. 1969. Technical Writing. Barnes & Noble.

Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.

Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.

PGS 503: Intellectual Property and Its Management In Agriculture 1(1+0) (e-Course)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH & Maredia K. 1998. Intellectual Property Rights in Agricultural Biotechnology. CABI. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504

Basic Concepts in Laboratory Techniques

1(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 vascupets; 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.

PGS 505:

Agricultural Research, Research Ethics and Rural Development Programmes (e-Course)

1(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 I

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 Research 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 II

_Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

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) 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. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions Issues, Innovations and Initiatives. Mittal Publ.

Singh K.. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PGS 506

Disaster Management (e-Course)

1(1+0)

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.