PG Degree Programme Syllabus as per BSMA, ICAR
M.Sc. (Agri.) Entomology

M.S. Swaminathan School of Agriculture
Centurion University of Technology and Management
Alluri Nagar, P.O. - R Sitapur, Via- Uppalada, Paralakhemundi
Dist: Gajapati – 761211
Odisha, India
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Preamble

THE curricula development is a part of the continued process and effort of the ICAR in this direction for dynamic improvement of national agricultural education system. In this resolve, the ICAR has constituted a National Core Group (NCG) for restructuring of Master's and Ph.D. curriculum, syllabi and academic regulations for the disciplines under agricultural sciences. On the recommendations of the NCG, 19 Broad Subject Matter Area (BSMA) Committees have been constituted by the ICAR for revising the syllabus. These Committees held discussions at length in the meetings and workshops organized across the country. The opinions and suggestions invited from institutions, eminent scientists and other stakeholders were also reviewed by the Committees. The respective BSMA Committees have examined the existing syllabus and analysed carefully in terms of content, relevance and pattern and then synthesized the new syllabus.

The revised curricula of 79 disciplines has been designed with a view to improve the existing syllabus and to make it more contextual and pertinent to cater the needs of students in terms of global competitiveness and employability. To mitigate the concerns related to agriculture education system in India and to ensure uniform system of education, several changes have been incorporated in common academic regulations in relation to credit load requirement and its distribution, system of examination, internship during Masters programme, provision to enrol for online courses and take the advantage of e-resources through e-learning and teaching assistantship for Ph.D. scholars. As per recommendations of the National Education Policy-2020, the courses have been categorized as Major and Minor/Optional courses. By following the spirit of Choice Based Credit System (CBCS), thestudents are given opportunity to select courses from any discipline/department enabling the multi-disciplinary approach.

We place on record our profound gratitude to Dr Trilochan Mohapatra, Director General, ICAR, New Delhi, for providing an opportunity to revise the syllabi for PG and Ph.D. programs in agriculture and allied sciences. The Committee is deeply indebted to Dr R.C. Agrawal, DDG (Agri. Edn), and to his predecessor Dr N.S. Rathore for their vision and continuous support. Our thanks are due to all Hon'ble Vice Chancellors of CAUs/SAUs/ DUs for their unstinted support and to nominate the senior faculty from their universities institutes to the workshops organized as a part of wider consultation process. The revised syllabi encompass transformative changes by updating, augmenting, and revising course urricula and common academic regulations to achieve necessary quality and need-based agricultural education. Many existing courses were upgraded with addition and deletion as per

the need of the present situation. The new courses have been incorporated based on their importance and need both at national and international level. We earnestly hope that this document will meet the needs and motivate different stakeholders.

Content

Framework of the courses

The following nomenclature and Credit Hrs. need to be followed while providing thesyllabus for all the disciplines

Courses	M.Sc. (Agri.) Credits
Major courses	**20**
Minor courses	**08**
Supporting courses	**06**
Common courses	**05**
Seminar	**01**
Thesis	**30**
Total	**70**

M.Sc. (Agri.) Entomology

ENTO 0518	Lac Culture	2+1	30
ENTO 0519	Molecular Approaches in Entomology	2+1	31
ENTO 0520	Plant Quarantine, Biosafety and Biosecurity	2+0	32
ENTO 0521	Edible and Therapeutic Insects	1+1	33
ENTO 0522	Medical and Veterinary Entomology	1+1	34
ENTO 0523	Forest Entomology	1+1	35
ENTO 0591	Seminar	0+1	
ENTO 0599	Research	30	
Minor Courses			
PATH 0504	Plant Nematology	2+1	37
PATH 0505	Principles of Plant Pathology	2+1	38
PATH 0506	Techniques in detection and diagnosis of plant diseases	0+2	39
MMBB 0501	Principles of Biotechnology	3+0	40
MMBB 0552	Basic Biochemistry	3+0	41
MMBB 0555	Introduction to Bioinformatics	2+1	42
Supporting Courses			
MMBB 0504	Techniques in Molecular Biology I	0+3	43
MMBB 0507	Techniques In Molecular Biology II	0+3	44
STAT 0511	Experimental Designs	2+1	45
Common Courses			
PGSS 0501	Library and Information Services	0+1	46
PGSS 0502	Technical Writing and Communications Skills	0+1	47
PGSS 0503	Intellectual Property and its Management in Agriculture	1+0	47
PGSS 0504	Basic Concepts in Laboratory Techniques	0+1	48
PGSS 0505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0	49

***Indicates core course which is compulsory course for M Sc.(Agri.)**

M.Sc. (Agri.) in Entomology Syllabus

MAJOR COURSES

Course Code: ENTO 0501
Credit Hours: 2+1
Course Title: Insect Morphology

Objective: To acquaint the students with the external morphology of the insect's body and thefunctioning of various body parts.

Theory

UNIT I

External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites.

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.

Abdomen- Segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development.

UNIT II

Insect sense organs (mechano-, photo- and chemo- receptors); organogenensis at pupal stage; insect defense; chaetotaxy; morphological traits in relation to forensic entomology.

UNIT III

Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemimetabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

- Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia; dissection of genitalia.
- Types of immature stages in insects; their collection, rearing and preservation.
- Identification of immature insects to orders and families, in endopterygote orders viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key.

Suggested Reading

Chapman, RF. 1998. The Insects: Structure and Function. Cambridge Univ. Press, Cambridge.

Duntson, PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
Evans, JW. 2004. Outlines of Agricultural Entomology. Asiatic Publ., New Delhi. Gillott, C. 1995. Entomology, 2nd Ed. Plenum Press, New York, London.
Gullan, P.J. and Cranston, P.S. 2000. The Insects, An Outline of Entomology, 2nd Ed. Blackwell Science, U.K.
Richards, OW and Davies, RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
Snodgross, RE. 1993. Principles of Insect Morphology. Cornell Univ. Press, Ithaca. Tembhore, D.B. 2000. Modern Entomology, Himalaya Publishing House, Mumbai. Chu, HF. 1992. How to Know Immature Insects. William Brown Publication, Iowa. Peterson, A. 1962. Larvae of Insects. Ohio University Press, Ohio.
Stehr, FW. 1998. Immature Insects. Vols. I, II. Kendall Hunt Publication, Iowa.

Course Code: ENTO 0502
Credit Hours: 2+1
Course Title: Insect Anatomy and Physiology

Objective: To impart knowledge about the anatomy and physiology of insect body systems; nutritionalphysiology; and their applications in entomology.

Theory
UNIT I
Scope and importance of insect physiology; physiology of integument, moulting, chemistry of cuticle, biosysthesis of chitin; growth, hormonal control, metamorphosis and diapause; pheromone secretion, transmission, perception and reception.

UNIT II
Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretion (exocrine & endocrine glands) and nerve impulse transmission in insects.

UNIT III
Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

Practical
- Latest analytical techniques for analysis of free amino acids of haemolymph.
- Determination of chitin in insect cuticle
- Examination and count of insect haemocytes
- Preparation and evaluation of various diets
- Cconsumption, utilization and digestion of natural and artificial diets.

Suggested Reading

Chapman RF. 1998. *Insects: Structure and Function*. ELBS Ed., London.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.

Gullan PJ and Cranston PS. 2000. *The Insects*: *An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.

Kerkut GA and Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology.* Vols. I-XIII. Pergamon Press, New York.

Patnaik BD. 2002. *Physiology of Insects*. Dominant Publishers, New Delhi.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Vol. 1. *Structure, Physiology and Development.* Chapman and Hall, New York.

Simpson SJ. 2007. *Advances in Insect Physiology*, Vol. 33, Academic Press (Elsevier), London, UK.

Wigglesworth VB. 1984. *Insect Physiology.* 8th Ed. Chapman and Hall, New York.

Course Code: ENTO 0503
Credit Hours: 1+2
Course Title: Insect Taxonomy

Objective: To sensitize the students on the theory and practice of classifying organisms (with special reference to animals) and the rules governing the same. 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 with an emphasis on the practical aspects.

Theory

UNIT I

History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy v/s homology, parallel v/s convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects- introduction to phylogeny of insects and Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses.Process of speciation and interbreeding allopatric species. Molecular systemnatics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labeling protocols and procedures.

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 Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

- Study of Orders of insects and their identification using taxonomic keys.
- Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera,Lepidoptera and Hymenoptera. Field visits to collect insects ofdifferent orders.

Suggested Reading

CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.

Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.

Gullan, P.J. and Cranston, P.S. 2010. The Insects: An outline of Entomology. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.

Mayr, E. 1971. Principles of Systematic Zoology. Tata McGraw Hill, New Delhi.

Richards OW and Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.

Ross HH.1974. Biological Systematics. Addison Wesley Publ. Company.

Triplehorn CA and Johnson NF. 1998. Borror and DeLong's Introduction to the Study of Insects. 7th Ed. Thomson/ Brooks/ Cole, USA/Australia.

Course Code: ENTO 0504
Credit Hours: 2+1
Course Title: Insect Ecology

Objective: To teach the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, constructing life tables, organization of communities, diversity indices. Train students in sampling methodology, calculation of diversity indices, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

UNIT I

History and definition. Basic Concepts. Organisation of the Biological world. Plato'sNatural

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. 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. Climate change and insect pest/ natural enemy population; ecological engineering.

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 samplesize. 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 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 Reading

Begon, M., Townsend, C.R. and Harper, J. L. 2006. Ecology: From Individuals to Ecosystems. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.

Chapman J. L. and Reiss MJ. 2006. Ecology: Principles and Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.

Fowler, J., Cohen, L. and Jarvis, P. 1998. Practical Statistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.

Gotelli N. J and Ellison AM. 2004. A Primer of Ecological Statistics. Sinauer Associates, Inc., Sunderland, MA.

Gotelli N. J. 2001. A Primer of Ecology. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA

Gupta RK. 2004. Advances in Insect Biodiversity. Agrobios, Jodhpur.

Krebs CJ. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.

Krebs CJ. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin- Cummings Publ. Co., New York.

Magurran AE. 1988. Ecological Diversity and its Measurement. Princeton Univ. Press,Princeton.

Price PW. 1997. Insect Ecology. 3rd Ed. John Wiley, New York.

Real LA and Brown JH. (Eds). 1991. Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, Chicago.

Schowalter, Timothy D. 2011. Insect Ecology – An Ecosystem Approach. 3rd Ed. Academic Press, London, UK/CA, USA.

Southwood TRE and Henderson PA. 2000. Ecological Methods. 3rd Ed. Methuen and Co. Ltd., London.

Speight MR, Hunta MD and Watt AD. 2006. Ecology of Insects: Concepts and Application. Elsevier Science, Publ., The Netherlands.

Townsend, Colin R., Begon, Michael and Harper, John L. 2008. Essentials of Ecology. 3rd Ed. Blackwell, Publishing, USA/ UK/ Australia.

Wilson EO and William H Bossert WH. 1971. A Primer of Population Biology. Harvard University, USA.

Wratten SD and Fry GLA.1980. Field and Laboratory Exercises in Ecology. Arnold,London.

Course Code: ENTO 0505
Credit Hours: 2+1
Course Title: Biological Control of Insect Pests and Weeds

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. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

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. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

UNIT III

Mass production of quality bio-control agents- techniques, formulations, economics, field release/ application and evaluation. Development of insectaries, their maintenance.

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 to bio-control laboratories to learn rearing and mass production of egg, egglarval, 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 Reading

Burges HD and 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 and Hall, New York.

Dhaliwal GS and Arora R. 2001. *Integrated Pest Management: Concepts and Approaches.* Kalyani Publishers, New Delhi.

Gerson H and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual.* Chapman and Hall, New York.

Huffaker CB and Messenger PS. 1976. *Theory and Practices of Biological Control.* Academic Press, London.
Ignacimuthu SS and 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 and Bellows TS. Jr. 1996. *Biological Control*. Chapman and Hall, New York

Course Code: ENTO 0506
Credit Hours: 2+1
Course Title: Toxicology of Insecticides

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; categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general; structure and mode of action oforganochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neo- nicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

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. bioassay definition, objectives, criteria, factors, problems and solutions.

UNIT IV
Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

UNIT V
Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

- Insecticide formulations and mixtures
- Laboratory and field evaluation of bio-efficacy of insecticides; bioassay techniques.
- Probit analysis; evaluation of insecticide toxicity.
- Toxicity to beneficial insects.
- Pesticide appliances.
- Working out doses and concentrations of pesticides.
- Procedures of residue analysis.

Suggested Reading

Chattopadhyay SB. 1985. Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.

Gupta HCL.1999. Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur.

Ishaaya I and 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 and Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.

Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publication, New York.

Pedigo, L.P. and Marlin, E. R. 2009. Entomology and Pest Management, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.

Dovener, R.A. Mueninghoff, J.C. and Volgar, G.C. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA

Dodia, D.A. Petel, I.S. and Petal, G.M. 2008. Botanical Pesticides for Pest Management. Scientific Publisher (India), Jodhpur.

Ishaaya, I. and Degheele, D. 1998. Insecticides with Novel Modes of Action: Mechanism and Application. Norosa Publishing House, New Delhi.

Mathews G.A. 2002. Pesticide Application Methods. 4th Ed. Intercept. UK.

Otto, D. and Weber, B. 1991. Insecticides: Mechanism of Action and Resistance. U.K.

Roy, N.K. 2006. Chemistry of Pesticides. Asia Printograph Shahdara Delhi.

Krieger, R. I. 2001. Handbook of Pesticide Toxicology. Vol-II. Academic Press. Orlando Florida.

Course Code: ENTO 0507
Credit Hours: 1+1
Course Title: Host Plant Resistance

Objective: To orient the students with host plant resistance.

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 nsects.

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 Reading

Dhaliwal GS and Singh R. (Eds). 2004. *Host Plant Resistance to Insects -Concepts and Applications.* Panima Publ., New Delhi.

Maxwell FG and Jennings PR. (Eds). 1980. *Breeding Plants Resistant to Insects.* John Wiley and Sons, New York.

Painter RH. 1951. *Insect Resistance in Crop Plants*. MacMillan, London.

Panda N and Khush GS. 1995. *Plant Resistance to Insects.* CABI, London.

Smith CM. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches.* Springer, Berlin.

Course Code: ENTO 0508
Credit Hours: 2+0
Course Title: Concepts of Integrated Pest Management

Objective: To familiarize the students with principles of insect pest management, including concept andphilosophy of IPM. Train students in computation of ETL and implementing IPM programmes.

Theory

UNIT I

History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons.

UNIT II

Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect host plant relationships; theories and basis of host plant selection in phytophagous insects.

UNIT III

Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semio-chemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organicfarming; components of ecological engineering with successful examples.

UNIT IV

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; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. 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.

Suggested Reading

Dhaliwal GS and Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publ., New Delhi

Horowitz AR and Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi.

Ignacimuthu SS and Jayaraj S. 2007. Biotechnology and Insect Pest Management. Elite Publ., New Delhi.

Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi.

Norris RF, Caswell-Chen EP and Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.

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

Course Code: ENTO 0509
Credit Hours: 2+1
Course Title: Pests of Field Crops

Objective: To familiarize the students about nature of damage and seasonal incidence of pestiferous Insects 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. Insect pest scenario in relation to climate change.

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

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

Unit III
Insect pests of fibre crops, forage crops, 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 Reading
David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology.* Popular Book Depot, Chennai.
Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology.* Kalyani Publishers, New Delhi.
Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publishers, 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 and Mathur RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.
Saxena RC and Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.

Course Code: ENTO 0510
Credit Hours: 2+1
Course Title: Pests of Horticultural and Plantation Crops.

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, 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 Reading

Atwal AS and Dhaliwal GS. 2002. *Agricultural Pests of South Asia and theirManagement.* Kalyani Publishers, New Delhi.

Butani DK and Jotwani MG. 1984. *Insects and Vegetables.* Periodical Expert Book Agency, New Delhi.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Srivastava RP. 1997. *Mango Insect Pest Management.* International Book Distr., Dehra Dun.

Verma LR, Verma AK and Goutham DC. 2004. *Pest Management in Horticulture Crops*: *Principles and Practices*. Asiatech Publ., New Delhi.

Course Code: ENTO 0511
Credit Hours: 2+1
Course Title: Post Harvest Entomology

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. Concept of seed vault.

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 controlprophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; 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 hidden insect infestation in stored food grains;
- Estimation of uric acid content in infested produce; 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, Mysore; IGSMRI, Hapur, etc. (only where logistically feasible).

Suggesting Reading

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 and Muir WE. 1995. *Stored Grain Ecosystem.* Marcel Dekker, New York.

Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publishers, New Delhi.

Khare BP. 1994. *Stored Grain Pests and Their Management.* Kalyani Publishers, New Delhi.

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

Course Code: ENTO 0512
Credit Hours: 1+1
Course Title: Insect Vectors of Plant Pathogens

Objective: To teach the students about the different groups of insects that act as vectors of plant pathogens, vector-plant pathogen interaction, and 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;
- Vector rearing and maintenance;
- Estimating vector transmission efficiency, studying vector-virus host interaction.

Suggested Reading
Basu AN. 1995. *Bemisia tabaci* (Gennadius) – *Crop Pest and Principal Whitefly Vector of Plant Viruses.* Oxford and IBH, New Delhi.
Harris KF and Maramarosh K. (Eds.). 1980. *Vectors of Plant Pathogens*. Academic Press, London.
Maramorosch K and Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.
Youdeovei A and Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

Course Code: ENTO 0513
Credit Hours: 1+1
Course Title: Principles of 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. Soil arthropods and their classification, habitats and their identification.

UNIT II
Introduction to morphology and biology of mites and ticks. Broad classification major orders

and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

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. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.

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 Reading

Anderson JM and Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.

Chhillar BS, Gulati R and Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.

Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley and Sons, New York.

Gerson U and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman and Hall, NewYork.

Gupta SK. 1985. *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta.

Gwilyn O and Evans GO. 1998. *Principles of Acarology*. CABI, London.

Jeppson LR, Keifer HH and 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.

Pankhurst C, Dube B and Gupta, V. 1997. *Biological Indicators of Soil Health.* CSIRO, Australia.

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 Publishers House, New Delhi.

Walter DE and Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviou*r. CABI, London.

Veeresh GK and Rajagopal D. 1988. *Applied Soil Biology and Ecology*. Oxford and IBH Publ., New Delhi.

Course Code: ENTO 0514
Credit Hours: 1+1
Course Title: Vertebrate Pest Management

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

Theory

UNIT I

Introduction to vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals.

UNIT II

Bio-ecology of birds of agricultural importance, patterns of pest damage and assessment, roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.

UNIT III

Bio-ecology of rodents of agricultural importance, patterns of pest damage and assessment, burrowing pattern and habitat of rodents; management of pestiferous rodents.

UNIT IV

Bio-ecology of higher vertebrates of agricultural importance, patterns of damage and assessment, their habitat; management of pestiferous vertebrates.

UNIT V

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, equipments and educative programmes.

Practical

- Identification of important rodents, birds and other vertebrate pests of agriculture, food preference and hoarding;
- Social behaviour, damage assessment, field survey, population estimation, management strategies: preventive and curative methods.

Suggested Reading

- Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay.
- Fitzwater WD and Prakash I. 1989. *Handbook of Vertebrate Pest Control.* ICAR, New Delhi.
- Prakash I and Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.
- Prakash I and Ghosh RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.

- Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay.
- Rahman A. 2020. *Protective and Productive Entomology* Narendra Publishing House, New Delhi.

Course Code: ENTO 0515
Credit Hours: 0+1
Course Title: Techniques in Plant Protection

Objective: To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, etc.

Practical

- Pest control equipments, principles, operation, maintenance, selection, and application of pesticides;
- Release of bio-control agents;
- Seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water;
- Application of drones in plant protection;
- Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers;
- Uses of light, transmission and scanning electron microscopy;
- Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE;
- Use of tissue culture techniques in plant protection;
- Computer application for predicting/ forecasting pest attack and identification.

Suggested Reading

Alford DV. 1999. *A Textbook of Agricultural Entomology.* Blackwell Science, London.
Crampton JM and Eggleston P. 1992. *Insect Molecular Science.* Academic Press, London.

Course Code: ENTO 0516
Credit Hours: 2+1
Course Title: Apiculture

Objective: To impart knowledge about the honey bees, and their behaviour and activities; bee husbandry, bee multiplication, bee enemies and diseases and their management; hive products, apitherapy; and managed bee pollination of crops.

Theory
UNIT I

Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races; Morphology and anatomy of honey bee; Honey bee

biology, ecology, adaptations; Honey bee behaviour – nest founding, comb construction, brood care, defense, other in-house and foraging activities; Bee pheromones; Honey bee communication.

UNIT II

Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting – causes and management; Curbing drone rearing; Laying worker menace – causes, signs and management.

UNIT III

Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages.

UNIT IV

Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptoms of damage, management tactics; Wax moths, wasps and ants – biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees.

UNIT V

Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.

UNIT VI

Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

Practical

- Morphological characteristics of honey bee;
- Mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees;
- Recording of colony performance;
- Seasonal bee husbandry practices;
- Swarming, queenlessness, swarming, laying workers menaces, etc. and their remedies;
- Innovative techniques in mass queen bee rearing; selection and breeding of honey bees;
- Instrumental insemination; formulation of artificial diets and their feeding;
- Production technologies for various hive products;

- Bee enemies and diseases and their management;
- Recording pollination efficiency;
- Application of various models for determining pollination requirement of crop;
- Developing a beekeeping project.

Suggested Reading

Abrol DP and Sharma D. 2009. *Honey Bee Mites and Their Management.* Kalyani Publishers, New Delhi, India.

Abrol DP. 2009. *Honey bee Diseases and Their Management*. Kalyani Publishers, New Delhi, India.

Abrol DP. 2010. *Beekeeping: A Compressive Guide to Bees and Beekeeping*. Scientific Publishers, India.

Abrol DP. 2010. *Bees and Beekeeping in India*. Kalyani Publishers, New Delhi, India.

Abrol DP. 2012. *Pollination Biology: Biodiversity Conservation and Agricultural Production.* Springer.

Atwal AS. 2001. *World of Honey Bees.* Kalyani Publishers, New Delhi- Ludhiana, India.

Atwal AS. 2000. *Essentials of Beekeeping and Pollination*. Kalyani Publishers, New Delhi-Ludhiana, India.

Bailey L and Ball BV. 1991. *Honey Bee Pathology*. Academic Press, London.

Crane Eva and Walker Penelope. 1983. *The Impact of Pest Management on Bees and Pollination.* Tropical Development and Research and Institute, London.

Free JB. 1987. *Pheromones of Social Bees.* Chapman and Hall, London.

Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. *Mass Multiplication of Honey Bee Colonies.* ICAR, New Delhi, India.

Grahm Joe M. 1992. *Hive and the Honey Bee.* Dadant & Sons, Hamilton, Illinois, USA.

Grout RA. 1975. *Hive and the Honey Bee.* Dadant & Sons, Hamilton, Illinois, USA.

Holm E. 1995. *Queen Rearing Genetics and Breeding of Honey Bees.* Gedved, Denmark.

Laidlaw HH Jr and Eckert JE. 1962. *Queen Rearing*. Berkeley, University of California Press.

Laidlaw HH. 1979. *Contemporary Queen Rearing*. Dadant & Sons, Hamilton, Illinois, USA.

Mishra RC. 2002. *Perspectives in Indian Apiculture*. Agro-Botanica, Jodhpur, India.

Mishra RC. 1995. *Honey Bees and their Management in India.* I.C.A.R., New Delhi, India.

Morse AA. 1978. *Honey Bee Pests, Predators and Diseases*. Cornell University Press, Ithaca and London.

Rahman, A. 2017. *Apiculture in India*, ICAR, New Delhi

Ribbands CR. 1953. *The Behaviour and Social Life of Honey Bees*. Bee Research Association Ltd., London, UK.

Rinderer TE. 1986. *Bee Genetics and Breeding.* Academic Press, Orlando.

Sardar Singh. 1962. *Beekeeping in India*. I.C.A.R., New Delhi, India (Reprint: 1982).

Seeley TD. 1985. *Honey Bee Ecology*. Princeton University Press, 216 pp.

Snodgrass RE. 1925. *Anatomy and Physiology of the Honey Bee*. Mc Graw Hill Book Co., New York & London.

Snodgrass RE. 1956. *Anatomy of the Honey Bee*. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

Course Code: ENTO 0517
Credit Hours: 2+1
Course Title: Sericulture

Objective: To familiarize the students with entrepreneurial opportunities in entomology, sericulture in particular, and providing information on silk worm rearing, production and management.

Theory

UNIT I

History of Sericulture, importance, organizations involved in sericulture activities, silkworm types, distribution, area and silk production.

UNIT II

Mulberry species, ecological requirements, cultivation, improved varieties, propagation methods, sapling production, planting and pruning techniques; pest and diseases, management strategies; intercropping, water and weed management. Food plants of eri silkworm, castor cultivation, intercultural operations, nutrient and water management; method of harvest; host plants of Tasar, nursery and cultivation, selection of seed, soaking and heap making, pruning techniques. Food plants of Muga silkworm, Som and Soalu propagation methods; nursery techniques; intercultural operations and weed management.

UNIT III

Silkworm origin – classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races –multivoltine and bivoltine races – cross breeds – bivoltine hybrids –Races and hybrids of mulberry, eri, tasar and muga silkworm- Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.

UNIT IV

Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.

UNIT V

Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.

Practical

- Morphology of mulberry plants;
- Identification of popular mulberry genotypes;
- Nursery bed and main field preparation;

- Planting methods;
- Identification of nutrient deficiency symptoms;
- Identification of weeds;
- Pruning and harvesting methods;
- Identification of pests and diseases of mulberry–*Terminalia arjuna, Terminalia tomentosa,* Som and Soalu- Nursery and pruning techniques – Intercultural operations;
- Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm egg production technology –Tasar, Eri and muga silkworms – rearing methods–pests and diseases of non-mulberry silkworms – Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.

Suggested Reading

Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.

Govindaiah G, VP, Sharma DD, Rajadurai S and Nishita V Naik. 2005. A text book on mulberry crop protection. Central Silk Board, Bangalore.450 p.

Jolly MS, Sen SK, Sonwalkar TN and Prasad GK. 1980. Non–mulberry Silks. FAO Agicultural

Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.

Mahadevappa D, Halliyal VG, Shankar DG and Ravindra Bhandiwad. 2000. Mulberry Silk Reeling Technology. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi. 234 p.

Mohanty PK. 2003. Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, 197 p.

Nataraju B, Sathyaprasad K, Manjunath D and Kumar A. 2005. Silkworm crop protection. CSB, Bangalore. 412 pp.

Rangaswami G, Narasimhanna MN, Kasiviswanathan K, Sastry CR and Jolly MS. 1976. Food Plants of non-mulberry silkworms. In: *Mulberry cultivation*. FAO Agricultural Services Bulletin. Vol.1, Chapter-13. Rome, Italy. 96 p.

Tribhuvan Singh and Saratchandra B. 2004. Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 pp.

Course Code: ENTO 0518
Credit Hours: 2+1
Course Title: Lac Culture

Objective: To familiarize the students with entrepreneurial opportunities in entomology with an emphasis on lac culture in particular. To provide information on lac insect rearing, production and management.

Theory
UNIT I

History of lac production; importance, potential of lac production in India; organizations

involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.

UNIT II

Steps and operation of lac production; lac host plant species, ecological requirements, their cultivation; seasons of host plants, harvest time of host plants, rearing seasons; grouping of host trees, pruning methods, timing; lac host plant pests and diseases; management strategies.

UNIT III

Basic morphology and taxonomy of lac insect, strains of lac insect and their characteristics; composition of lac; biology of lac insect, species diversity and distribution.

UNIT IV

Introduction, lac insect-host plant interaction; selection of brood lac, local practices, improved alternatives, coupe system; propagation of lac insects: natural self inoculation, artificial inoculation; inoculation process and duration; removal of phunki, harvesting of lac, immature harvesting, mature harvesting and time of harvesting. Predators and parasitoids of lac insect, hyperparasites, diseases and their management.

UNIT V

Lac production stages; factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method; technology of brood preserving. Host-specific technologies – cultivation on specific host plants; integration of lac cultivation with agro-forestry and horticulture; socio-economic potential of lac; export-import of lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.

Practical

- Lac host cultivation and lac production practices;
- Equipments for lac production;
- Conventional and advanced methods;
- Coupe system of lac production;
- Cultivation of suitable host plants;
- Pruning of host trees;
- Herbarium of host plants;
- Strains of lac insects;
- Brood lac selection and treatment for pest management;
- Slide preparation of adult and immature stages;
- Inoculation of host tree;
- Identification of natural enemies of lac insect and their management;
- Molecular characterization of lac insect where possible;
- Harvesting;
- Process of manufacture of seed lac, shell lac from stick lac;

- Grading of seed lac and shellac;
- Marketing of lac products and by products.

Suggested Reading

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.
Sharma KK and Ramani S. 2010. *Recent advances in lac culture*. ICAR-IINRG, Ranchi.

Course Code: ENTO 0519
Credit Hours: 2+1
Course Title: Molecular Approaches in Entomology.

Objective: To acquaint students the latest techniques used in molecular biology.

Theory
UNIT I
Introduction to molecular biology, techniques used in molecular biology**.**

UNIT II
DNA recombinant technology, identification of genes/ nucleotide sequences for traits of interest, techniques of interest in plants and microbes.

UNIT III
Genes of interest in entomological research- marker genes for sex identification, peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Plantderived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terepenes and terpenoids; genes of non-plant origin, Bacillus thuringiensis endotoxins, mode of action of cry genes, classification and properties, synthetic Bt toxin genes, Other toxin genes, genes derived from entomophagous viruses, transgenic plants for pest resistance.

UNIT IV
Genetically engineered microbes and parasitoids in biological control-Genetic engineering in baculoviruses and fungal biocontrol agents for greater efficacy against insect pests. Effects of transgenic plants on pest biology and development, resistance management strategies in transgenic crops, molecular mechanism of insecticide resistance.

UNIT V
Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique and relase of insects carrying a dominant lethal gene. Methods and application of insect trangenesis, transgenics in silkworm and honeybees. Molecular tools for taxonomy and phylogeny of insectpests, DNA-based diagnostics. Nano technology and its application.

Practical

- Isolation of DNA/ RNA
- Agarose gel electrophoresis of DNA, quantification of DNA by spectrophotometirc and agarose gel analysis, PCR amplification of mitochondrial cytochrome oxidase subunit I gene (cox1) and 16S rRNA gene, cloning of PCR amplicons in standard plasmid vectors for sequencing, confirmation of the insert, miniprep of recombinant plasmid DNA, BLAST analysis and multiple sequence alignment of the sequence with sequences already available in GenBank
- Isolation of host plant proteins, SDS-PAGE of the isolated proteins

Suggested Reading

Bhattacharya TK, Kumar P and Sharma A. 2007. Animal Biotechnology. 1st Ed., Kalyani Publication, New Delhi.

Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. Molecular Insect Science. Plenum Press, New York.

Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.

Oakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer Verlag.

Rechcigl JE and Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.

Roy U and Saxena V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publishers, New Delhi.

Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publishers, New Delhi.

Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publishers, New Delhi.

Course Code: ENTO 0520
Credit Hours: 2+0
Course Title: Plant Quarantine, Bio-safety and Bio-security.

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. Also, to facilitate students to have agood understanding of the aspects of biosafety and biosecurity.

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.

Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procdures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

UNIT III

Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.

UNIT IV

WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. 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. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

Suggested Reading

Rajeev K and 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.

Shukla A and Veda OP. 2007. *Introduction to Plant Quarantine*. Samay Prakashan, New Delhi.

Course Code: ENTO 0521
Credit Hours: 1+1
Course Title: Edible and Therapeutic Insects.

Objective: To create awareness and acquaint students about the contribution that insects make to ecosystems, diets, food security and livelihoods in developed and developing countries.

Theory

UNIT I

Edible and therapeutic insects: the concept, definition, and importance.

UNIT II

History and origin of insects as food, feed and medication; important insect species and insect products consumed.

UNIT III

Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing.

UNIT IV

Nutritional composition and role of insects in food security.

UNIT V

Insect farming: the concept, definitions, and rearing techniques.

UNIT VI

Processing edible insects for food and feed.

Unit VII

Food safety and preservation, edible insects for livelihood security.

Practical

- Survey and identification of edible and therapeutic insect species;
- Collection and preservation of edible and therapeutic insect specimens;
- Rearing techniques of edible insect species;
- Harvesting techniques of edible insects from natural environment;
- Analysis of proximate elemental composition, antioxidant and anti-nutritional properties and microbial aspects of preservation.

Suggested Reading

Halloran A, Flore R, Vantomme P and Roos N 2018. Edible insects in sustainable food systems.

Van Huis A, Itterbeeck JK, Klunder H, Mertens E, Halloran A, Muir G and Vantomme. 2013. Edible insects: future prospects for food and feed security. Food and Agricultural Organization of the United Nations, Rome.

Course Code: ENTO 0522
Credit Hours: 1+1
Course Title: Medical and Veterinary Entomology.

Objective: To study the major insect, mite, and tick vectors of disease to man and animals. Students will learn to identify and understand the life cycles, morphology, and behavior of mosquitoes, ticks, mites, lice, fleas, and other disease vectors.

Theory

UNIT I

Introduction to medical, veterinary and forensic entomology; Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; flies (Diptera) of medical and veterinary Importance; moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae).

UNIT II

Mosquito taxonomy, biology, and behavior; mosquito viruses: EEE, VEE, SLE, yellow fever,mosquito surveillance; malaria; horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary Importance; filariasis: mansonellosis, onchocerciasis.

UNIT III

Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, etc.; mites: rickettsial pox; mites and acariasis: mange, scabies, chiggers; spiders and scorpions; fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus.

UNIT IV

Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia; true bugs (Hemiptera): kissing bugs and bedbugs; chagas disease; tsetse flies; Lepidoptera and Hymenoptera of medical and veterinary importance.

Practical

- Identification of arthropod Classes, Orders and Families of medical and veterinary importance;
- Collection, segregation, curing insect and arachnid specimens, their preservation;
- Management of insect and mite pests of medical and veterinary importance;
- Study of some practical aspects in forensic entomology.

Suggested Reading

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

Gullan PJ and Cranston PS. 2010. *The Insects: An Outline of Entomology*. 4th Edition, Wiley-Blackwell, West Sussex, UK & New Jersey, US.

Mullen G and Durden L. 2018. *Medical and Veterinary Entomology*, 3rd Edition, Academic Press.

Course Code: ENTO 0523
Credit Hours: 1+1
Course Title: Forest Entomology

Objective: To promote a more global theoretical understanding of pest population dynamics and the causes of forest insect outbreaks: covering pests of both natural forests and plantations, the diversity of tropical forest insects, their ecological functions, the concept of pests and the incidence of pests in natural forests, plantations and stored timber.

Theory

UNIT I

Introduction to forestry in the tropics, tropical forests: characteristics and types of tropical forests, management of tropical forests and the problems in their management; plantation forestry: beginnings, expansion and current status.

UNIT II

History of tropical forest entomology, diversity of forest insects: structural and functional diversity – the feeding guilds, concept of pests, ecology of insects in forest environment, concept and functioning of ecosystem, role of insects in ecosystem processes of tropical forests: insects as primary consumers, secondary and tertiary consumers, as decomposers, as food, pollinators and other ecological interactions.

UNIT III

Insect pests in natural forests, general pest incidence, pest outbreaks: Lepidoptera, Coleoptera, Hemiptera, and Hymenoptera; insect pests in plantations, nursery pests, sapling pests, pests of older plantations and their impact; insect pests of stored timber, categories of wood destroying insects and their damage: termites and beetles.

UNIT IV

Population dynamics, characteristics of population growth, factors affection population growth, principles governing population dynamics, types and causes of forest insect outbreaks; general issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis; pest problems in plantations of indigenous *vs* exotic species; pest problems in monocultures *vs* mixed plantations.

UNIT V

Management of tropical forest insect pests, historical development and present status of tropical forest pest management, overview of pest management options: preventive measures, remedial measures; unique features of forest pest management; constraints to forest pest management in the tropics; guidelines for the practice of forest pest management in the tropics.

UNIT VI

Insect pests in plantations: Location-specific case studies.

Practical

- Collection, identification and preservation of important insect pest specimens of forest plants and some damage material;
- Detection of insect infestation and assessment of losses due to insect pests;
- Habitat management for vertebrate and insects pests;
- Fire control methods and devices;
- Familiarization with the meteorological and plant protection equipment, application of pesticides and bio-control agents in the management of insect pests in nurseries and plantations.

Suggested Reading

Jha LK and Sen Sarna PK. 1994. *Forest Entomology*. Ashish Publishing House, Delhi.

Nair KSS. 2007. *Tropical Forest Insect Pests: Ecology, Impact, and Management*, Cambridge University Press, Edinburgh/ New York.

Stebbings EP. 1977. *Indian Forest Insects*. JK Jain Brothers.

MINOR COURSES

Course Code: PATH 0504
Credit Hours: 2+1
Course Title: Plant Nematology

Objective: To project the importance of nematodes in agriculture and impart basic knowledge on allaspects of plant nematology.

Theory

UNIT I

Characteristics of Phylum Nematoda and its relationship with other related phyla, 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 organisms.

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.

UNIT VI

Emerging nematode problems, Importance of nematodes in international trade and quarantine.

Practical

- Studies on kinds of nematodes- free-living, animal, insect and plant parasites
- Nematode extraction from soil
- Extraction of migratory endoparasites, staining for sedentaryendoparasites
- Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

Suggested Reading

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

Maggenti AR. 1981. *General Nematology*. Springer-Verlag, New York.

Perry RN & Moens M. 2013. *Plant Nematology*. 2nd Ed.CABI Publishing: Wallingford, UK.

Perry RN, Moens M, & Starr, JL. 2009. *Root-knot nematodes*, CABI Publishing: Wallingford, UK

Sikora RA, Coyne D, Hallman J and Timper P, 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture.*3rd edn. CABI Publishing, England.

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

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

Walia RK. & Khan MR. 2018. *A Compendium of Nematode Diseases of Crop Plants*, ICARAICRP (Nematodes), IARI, New Delhi.

Course Code: PATH 0505

Credit Hours: 2+1

Course Title: Principles of Plant Pathology

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 developmentrole 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.

Practical

- Basic plant pathological techniques.
- Isolation, inoculation and purification of plant pathogens and proving Koch's postulates.
- Techniques to study variability in different plant pathogens.
- Purification of enzymes, toxins and their bioassay.
- Estimation of growth regulators, phenols,phytoalexins in resistant and susceptible plants.

Suggested Reading

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 2017. *Introduction to Principles of Plant Pathology*. 5th edn. MedTech, New Delhi.

Singh RP 2012. *Plant Pathology* 2nd edn. Kalyani Publishers, 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.

Course Code: PATH 0506

Credit Hours: 0+2

Course Title: Techniques for Detection and Diagnosis of Plant Diseases

Objective: To impart training on various methods/techniques/instruments used in the study of plantdiseases/pathogens

Practical

- Detection of plant pathogens 1. based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid based techniques (Non-PCR– LAMP, Later flow microarray & PCR based- multiplex, nested, qPCR, immune capture PCR, *etc.*). Phenotypic and genotypic tests for

identification of plant pathogens. Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region)and whole genome sequencing.

- Volatile compounds profiling by using GC MS and LC-MS. FAME analysis, Fluorescence in-situ Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens. Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

Suggested Reading

Baudoin ABAM, Hooper GR, Mathre DE & Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.

Dhingra OD & Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.

Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology,* CABI Wallington.

Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.

Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi Forster D & Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance*. *Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.

Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agic. Pub. Doc. Wageningen.

Trigiano RN, Windham MT & Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida.Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

Course Code: MMBB 0501
Credit Hours: 3+0
Course Title: Principles of Biotechnology

Objectives: To understand the basics of Molecular biology, plant and microbial Biotechnology. Importance and applications in agriculture, case studies and success stories. Public education, perception, IPR and related issues

Theory

UNIT I

History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology etc. Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities.

UNIT II

Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors;

Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

UNIT III

Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications.Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics. Plant cell and tissue culture techniques and their applications.

UNIT IV

Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions,Success stories in Biotechnology, Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Suggested Reading

Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M &Losick R (2014) Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York

Brown, T. A. (2010) Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell

Primrose, S. B. and Twyman, R. (2006) Principles of gene Manipulation 7th edition, Wiley Blackwell

Singh, B. D, Biotechnology: Expanding Horizons (2012) 4th edition, Kalyani publisher, New Delhi, India

Course Code: MMBB 0552
Credit Hours: 3+0
Course Title: Basic Biochemistry

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

Theory

UNIT I

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

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

UNIT III

Structure and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action. Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

UNIT IV

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

Practical

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

Suggested Reading

Conn EE & Stumpf PK. 1987. *Outlines of Biochemistry*.

John Wiley.Metzler DE. *Biochemistry.* Vols. I, II. Wiley International.

Nelson DL & Cox MM. 2004. *Lehninger's Principles of Biochemistry.* MacMillan. Voet D & Voet JG. *Biochemistry*. 3rd Ed. Wiley International.

Course Code: MMBB 0555
Credit Hours: 2+1
Course Title: Introduction to Bioinformatics

Objectives: To get a basic overview of computational techniques related to DNA, RNA and protein analysis. To get a hands on training in software's and programs used to analyse, assemble orannotate genomes, phylogenetics, proteomics etc.

UNIT I

Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, GenBank, DDBJ, secondary database, structural databases –PDB,SCOP and CATH, Specialized genomic resources, Microarray database.

UNIT II

Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequence analysis, Sequence submission and retrieval system-SEQUIN, BANKit, SAKURA, Webin, Sequence alignment, pair wise alignment techniques, multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants; Phylogenetic analysis- CLUSTAL X, CLUSTAL W, Phylip, Tcoffee

UNIT III

Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3DStructure Prediction: Evaluation of models- Structure validation and refinement - Ramachandran plot, Force field calculations, SAVES. Protein function prediction- sequence and domain based, Primer designing- principles and methods.Drug discovery**,** Structure Based Drug Design- Rationale for computer aided drug designing, basic principles, docking, QSAR.

Practical

- Usage of NCBI resources
- Retrieval of sequence/structure from databases and submission Different Databases, BLAST exercises.
- Assembly of DNA and RNA Seq data
- Annotation of assembled sequences,Phylogenetics and alignment
- Visualization of structures, Docking of ligand receptors
- Protein structure analysis and modeling

Suggested Reading

Attwood, T. K., and Parry-Smith, D. J. (2004) Introduction to Bioinformatics, Pearson Education (Singapore) Pvt. Ltd.

David Edwards (Ed.) (2007) Plant Bioinformatics: Methods and Protocols. Humana Press, New Jersey, USA.

Mount, D. W. (2004) Bioinformatics: Sequence and Genome Analysis 2nd Revised edition Cold Spring Harbor Laboratory Press, U.S.

Jonathan Pevsner (2009) Bioinformatics and Functional Genomics, 2nd edition, Wiley-Blackwell.

SUPPORTING COURSES

Course Code: MMBB 0504
Credit Hours: 0+3
Course Title: Techniques in Molecular Biology I

Objectives: To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology. To get a hands-on training in chromatography, protein analysis, nucleic acid analysis,bacterial and phage genetics

Practical

- Good lab practices, preparation of buffers and reagents.
- Principle of centrifugation and spectrophotometry.
- Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNAfrom bacteria.
- Isolation of plasmid DNA from bacteria.
- Growth of lambda phage and isolation of phage DNA.

- Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Merigold). Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry PCR using isolated DNA.
- PAGE Gel electrophoresis.
- Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction.Transformation of *E. coli* and selection of transformants
- Chromatographic techniquesTLC
- Gel Filtration Chromatography,Ion exchange Chromatography,Affinity Chromatography
- Dot blot analysis, Southern hybridization,Northern hybridization.
- Western blotting and ELISA.
- Radiation safety and non-radio isotopic procedure.

Suggested Reading

Sambrook, J., and Russell, R.W (2001) Molecular cloning: A laboratory manual 3rdEdition, Cold spring harbor laboratory press, cold spring harbor, New York.

Wilson, K., and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology 8th edition, Cambridge University Press.

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 5th edition, Current Protocolspublication .

Course Code: MMBB 0507
Credit Hours: 0+3
Course Title: Techniques in Molecular Biology II

Objectives: To get a basic overview of molecular biology techniques, good lab practices and molecular markers. To get a hands on training in RNAi, microarrays, yeast2 hybrid and immunologicaltechniques.

Practicals

- Construction of gene libraries (cDNA and Genomics).Synthesis and cloning of cDNA.
- Real time PCR and interpretation of data.Molecular markers RAPD. SSR. AFLP / ISSR and their analysis.
- Case study of SSR markers - construction of linkage map.QTL analysis using genotypic data based on SSR .
- SNP identification and analysis.
- Microarray studies and use of relevant software.
- Proteomics2D gels,
- Mass spectrometry
- RNAi - designing of construct, phenotyping of the plant.Yeast 1 and 2-hybrid interaction.
- Generation and screening of mutants.Transposon mediated mutagenesis.
- Immunology and molecular diagnostics: Ouchterlony double diffusion, Immunoprecipitation, Radiation Immunodiffusion, Immunoelectrophoretic, Rocket

Immunoelectrophoretic, Counter Current Immunoelectrophoretic,ELISA, Latex Agglutination, Immunohistochemistry.

Suggested Reading

Wilson, K., and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology 8th
Edition, Cambridge University Press
Bonifacino, J. S., Dasso, M., Harford, J. B., Liipincott-Schwartz, J., and Yamada, K. M., (2004), ShortProtocols in Cell Biology. John Wiley & Sons, New Jersey

Course Code: STAT0511
Credit Hours: 2+1
Course Title: Experimental Designs

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 ~ Lattice design, alpha design - concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

Practical

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law
- Analysis of data obtained from CRD, RBD, LSD
- Analysis of factorial experiments without and with confounding
- Analysis with missing data
- Split plot and strip plot designs
- Transformation of data
- Analysis of resolvable designs
- Fitting of response surfaces.

Suggested Reading

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.

COMMON COURSES

Course Code: PGSS0501
Credit Hours: 0+1
Course Title: Library and Information Services

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; eresources access methods.

Course Code: PGSS0502
Credit Hours: 0+1
Course Title: Technical Writing and Communications Skills

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 communication; 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 Reading

Chicago Manual of Style. 14thEd. 1996 Prentice Hall of IndiaCollins' Cobuild English Dictionary.1995
Harper Collins.Gordon HM & Walter JA. 1970.
Technical Writing 3rdEd. Holt, Rinehart &Winston'abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research.

Course Code: PGSS0503
Credit Hours: 1+0
Course Title: Intellectual Property and Its Management in Agriculture

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 Reading

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.

Course Code: PGSS0504

Credit Hours: 0+1

Course Title: Basic Concepts In Laboratory Techniques

Objective: To acquaint the students about the basic of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab; Handling of chemical substances
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware
- Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution
- Handling techniques of solutions; preparation of different agro-chemical doses in field and pot application
- 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 Reading

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

Gabb MH &Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

Course Code: PGSS0505
Credit Hours: 0+1
Course Title: Agricultural Research, Research Ethics and Rural Development Programmes

Objective: To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research, and rural development programmes and policies of Government.

Theory
UNIT I
History of agriculture in brief; Global agricultural research system: need, scope, opportunitites; 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 Organizations. Critical evaluation of rural development policies and programmes.Constraints in implementation of rural policies and programmes.

Suggested Reading
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