

# 11 Entomology

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## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

	L	P
<b>AGR 005</b> MAJOR PESTS OF CROPS AND THEIR MANAGEMENT	1	2
<b>ENT 500</b> INSECT BIODIVERSITY	2	1
<b>ENT 501</b> INSECT MORPHOLOGY	2	1
<b>ENT 502</b> PEST MANAGEMENT IN FIELD CROPS	2	1
<b>ENT 503</b> INSECT PEST MANAGEMENT	3	0
<b>ENT 505</b> PRINCIPLES OF BIOLOGICAL CONTROL	2	1
<b>ENT 507</b> PRINCIPLES OF INSECT PHYSIOLOGY	2	1
<b>ENT 509</b> HISTORY OF ENTOMOLOGY	1	0
<b>ENT 606</b> INSECT BIOCHEMISTRY	2	1
<b>ENT 691</b> SEMINAR	1	0

### II TRIMESTER

<b>ENT 506</b> PRINCIPLES OF INSECT ECOLOGY	2	1
<b>ENT 508</b> PRINCIPLES OF INSECT TOXICOLOGY	2	1
<b>ENT 512/</b> NANOTECHNOLOGY IN CROP PROTECTION	2	1
<b>AC 512/</b>		
<b>PL. PATH</b>		
<b>521/</b>		
<b>NEMA</b>		
<b>513/</b>		
<b>MB 512</b>		
<b>ENT 600</b> INSECT BIOSYSTEMATICS	2	1
<b>ENT 602</b> ADVANCES IN BIOLOGICAL CONTROL	2	1
<b>ENT 603</b> PESTS OF HORTICULTURAL AND PLANTATION CROPS	2	1
<b>ENT 608</b> ADVANCES IN INSECT PHYSIOLOGY	2	1
<b>ENT 610</b> INSECT GENETICS AND MOLECULAR BIOLOGY	2	1
<b>ENT 691</b> SEMINAR	1	0

### III TRIMESTER

ENT 504	POST HARVEST ENTOMOLOGY	2	1
ENT 601	INSECT PATHOLOGY	2	1
ENT 604	INSECT NUTRITION AND HOST PLANT RESISTANCE	2	1
ENT 605	ADVANCES IN INSECT TOXICOLOGY	2	1
ENT 607	BIOCHEMISTRY OF INSECTICIDE ACTION	2	1
ENT 609	RECENT TRENDS IN ENTOMOLOGY	2	1
ENT 611/	PLANT HEALTH DIAGNOSTICS & MANAGEMENT	2	2
PL PATH			
607			
ENT 691	SEMINAR	1	0

#### Core Courses:

**For M.Sc.: With in the discipline:** ENT 500, ENT 501, ENT 505, ENT 506, ENT 507, ENT 508

**Outside the discipline:** PGS 504

# ENTOMOLOGY

**Major Fields :** Insect Biosystematics  
Insect Pest Management (Ecology and Biological Control)  
Insect Toxicology  
Insect Physiology

**Minor Fields :** Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.  
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

## DESCRIPTION OF COURSES

### AGR 005 MAJOR PESTS OF CROPS AND THEIR MANAGEMENT

(1L+2P) I

#### Objective

To impart basic knowledge of insect pest and related problems to the non-agricultural graduates so that they can understand the whole gamete of agriculture for effective research programmes.

#### Theory

##### UNIT I

Introduction to Entomology: Position of insects in animal kingdom and brief history of Entomology in India; non-insect pests and pollinators.

##### UNIT II

Insect Pests of important crops and their management:

Cereals: Paddy, barley, wheat, sorghum, and maize.

Pulses: Pigeon pea, chickpea, mung bean, cowpea, and lentil.

Oil seeds: Mustard, groundnut, castor, and jatropha.

Vegetables: Cole crops, okra, cucurbits, potato, garden peas, and spinach.

Fruits: Mango, guava, banana, citrus, ber, and aonla.

Cotton.

Sugarcane.

##### UNIT III

Pests of storage and their management: Beetle insects, moth insects, mites, fungi, birds, and rodents.

##### UNIT IV

Pesticide application appliances and their safe handling: Sprayers, dusters and miscellaneous equipments.

## Practicals

Study of grasshoppers, study of garden slug and its stages, study of Termitarium, termite soldier and workers, distinguishing characters between insect and mite, study of damage symptoms caused by common grasshoppers and birds, study of rodent burrows and identification of live burrows, preparation of rat baits and its application in the live burrows. Study of pesticide labels for toxicity and safe handling, pesticide application equipments - sprayer, duster etc. Study of soil inhabiting pests (cutworms, white grubs, black ants, and nematodes). Study of insect trap, light trap, sticky trap, pheromone trap, and rat trap. Collection and study of insects from pulses, paddy, cotton, vegetables, cereals, oil seeds, fruits, and storage. Calculation of pesticide doses and preparation of stock solution. Study of useful insects (parasites, predators, and pollinators).

## Suggested Readings

Nair, M.R.G.K. 1986. *Insect and Mites of Crops in India*. ICAR, New Delhi.

Pradhan, S. 1969. *Insect Pests of Crops*. National Book Trust, India, 208p.

Regupathy, A.N., Chandramohan, S., Palanisamy and Gunathilagaraj, K. 2003. *A Guide on Crop Pests*. TNAU, Coimbatore, 276.

## ENT 500 INSECT BIODIVERSITY

(2L+IP) I

### Objective

To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families in insects.

### Theory

#### UNIT I

Introduction to class Insecta and its position in phylum Arthropoda; history of insect classification; phylogeny, evolution and nomenclature; diversity of insect and mite fauna in various ecosystem; importance of biodiversity in relation to agriculture and environment.

#### UNIT II

Classification of insects up to orders and identification of agriculturally important families in major insect orders of agricultural importance.

#### UNIT III

Methods of collecting, preserving and studying insects and their immature stages. Visits to ZSI, NBAIL, BNHS etc.

## Practicals

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

## Suggested Readings

Freeman, S. and Herron, J.C. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Richards, O.W. and Davies, R.G. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.

Ross, H.H. 1974. *Biological Systematics*. Addison Wesley Publ. Co.

Triplehorn, C.A. and Johnson, N.F. 1998. *Borror and DeLong's Introduction to the Study of Insects*. 7th Ed. Thomson / Books / Cole, USA / Australia.

## ENT 501 INSECT MORPHOLOGY

(2L+1P) I

### Objective

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

### Theory

#### UNIT I

Insect dominance, structural perfections and developmental characteristics; embryology and post embryonic development.

#### UNIT II

Integument, its structure, functions; head, its origin, segmentation, sclerites, sutures; types of antennae; mouth parts and their modifications; sensilla on various appendages; tentorium, neck and its sclerites.

#### UNIT III

Thorax, its sclerites and modifications; wing venation, articulation and wing coupling; legs and their modifications.

#### UNIT IV

Abdomen, its sclerites, appendages, glands on the body surface and external genitalia.

### Practicals

Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia; sense organs.

### Suggested Readings

Chapman, R.F. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.

David, B.V. and Ananthkrishnan, T.N. 2004. *General and Applied Entomology*. Tata-McGraw Hill, New Delhi.

Duntson, P.A. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Pub., New Delhi.

Evans, J.W. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.

Richards, O.W. and Davies, R.G. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.

Saxena, R.C. and Srivastava, R.C. 1977. *Entomology: At a Glance*: Agrotech Publ. Academy, Jodhpur.

Snodgrass, R.E. 1993. *Principles of Insect Morphology*. Council Univ. Press, Ithaca, USA.

## ENT 502 PEST MANAGEMENT IN FIELD CROPS

(2L+1P) I

### Objective

To familiarize the students about nature of damage and seasonal incidence of insect pests that causes loss to major field crops and their effective management by different methods.

### Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests, and vectors.

#### UNIT I

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

#### UNIT II

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

#### UNIT III

Insect pests of fibre crops, forages, sugarcane and their management.

### Practicals

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

### Suggested Readings

- Atwal, A.S., Dhaliwal, G.S. and David, B.V. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.
- Dhaliwal, G.S., Singh, R. and Chillar, B.S. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
- Dunston, A.P. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publ., New Delhi.
- Evans, J.W. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.
- Nair, M.R.G.K. 1986. *Insect and Mites of Crops in India*. ICAR, New Delhi.
- Prakash, I. and Mathur, R.P. 1987. *Management of Rodent Pests*. ICAR, New Delhi.
- Saxena, R.C. and Srivastava, R.C. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.

## ENT 503 INSECT PEST MANAGEMENT

(3L+0P) I

### Objective

To familiarize the students with principles of insect pest management, including concept and philosophy of integrated pest management (IPM). Train students in computation of ETL, implementing IPM programmes.

### Theory

#### UNIT I

History and concepts; ecological and sociological aspects; determination of single- and multi-pest economic injury level, and natural enemy- based economic levels.

## UNIT II

Dimensions of insect plant interactions and advances in varietal resistance including transgenics to crop pests; biological, chemical, legal, cultural, genetic, behavioural and other management tactics and development of PM modules; impact assessment.

## UNIT III

Analysis of spatial distribution, sampling, measuring economic levels of damage and modeling; biotype development and importance of biosystematics in pest diagnostics; bio-intensive IPM; bio-pesticides and toxicology in pest management, sanitary and phytosanitary measures; effect of radiations on insects, sterile male techniques.

## UNIT IV

Wide area management of epidemics of crop pests; case studies on pests of national importance and their management.

### Suggested Readings

- Dhaliwal, G.S. and Arora, R. 2003. *Integrated Pest Management - Concepts and Approaches*. Kalyani Publ., New Delhi.
- Dhaliwal, G.S., Singh, R. and Chillar, B.S. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
- Flint, M.C. and Brosch, R.V. 1981. *Introduction to Integrated Pest Management*. 1st ED., Springer, New York.
- Horowitz, A.R. and Ishaaya, I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.
- Ignacimuthu, S.S. and Jayaraj, S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.
- Metcalf, R.L. and Luckman, W.H. 1982. *Introduction of Insect Pest Management*. John Wiley & Sons, New York.

## ENT 504 POST HARVEST ENTOMOLOGY

(2L+IP) III

### Objective

To familiarize students with different pests associated with stored commodities and bulk storage, storage structures and safe use of fumigant. Besides, exposure to handle the agri-horticultural produce for contamination free trading, treatment protocols, and other sanitary and phytosanitary regulations.

### Theory

#### UNIT I

Bionomics and biology of pests of stored products including fungi, mites, rodents, and other non-insect pests.

#### UNIT II

Principles and methods of safe storage, detection methods, seed disinfection, and estimation of losses caused by the pests. Improved storage structures, warehouses, grain storage facilities and their management, insect trapping devices used in storage, and use of plastics in storage.

### UNIT III

Systems approach for quarantine security, fumigation with conventional and inert gases including modified atmosphere, vacuum fumigation, vapour heat treatment, hot water treatment, pesticidal dip, gamma irradiation, and microwave heat treatment.

### UNIT IV

Sanitary and phytosanitary considerations as well as Montreal Protocol.

### Practicals

Demonstration of losses in storage by insects, identification of storage insects (Adult and immature stages), moisture maintenance, storage material damaged by insects, storage structures, and fumigation.

### Suggested Readings

Cotton, R.T. 1963. *Insect Pests of Stored Grain and Grain Products*. Bergers Publ. Co. Minneapolis, Minn., USA. 242 pp.

Hall, D.W. 1970. *Handling and Storage of food grains in Tropical and Subtropical areas*. FAO Publ. No. 90. 345 pp.

Munro, H.A.U. 1969. *Manual of Fumigation for Insect Control*. FAO Publ. Plant Production and Protection Series No. 20 380pp.

Sinha, R.N. and Muir, W.E. 1973. *Grain Storage: Part of a System*. AVI Publishing Company. 461 pp.

## ENT 505 PRINCIPLES OF BIOLOGICAL CONTROL

(2L+1P) I

### Objective

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

### Theory

#### UNIT I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control-importation, augmentation and conservation.

#### UNIT II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc. Biological control of weeds using insects.

#### UNIT III

Mass production techniques of quality bio-control agents and economics.

#### UNIT IV

Methods of natural enemy colonization, recovery, evaluation and conservation. Pest-natural enemy ratios; biological control of important crop pests and weeds.

#### UNIT V

Establishment of biocontrol laboratories and related infrastructure.



## UNIT VI

Successful biological control projects, analysis, trends and future possibilities of biological control; importation of natural enemies-quarantine regulations; biotechnology in biological control; and semiochemicals in biological control.

### Practicals

Identification of common natural enemies of crop pests (parasitoids, predators, and microbes), and weed killers. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids; common predators; microbes and their laboratory hosts; and phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, and identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

### Suggested Readings

Burges, H.D. and Hussey, N.W. (Eds.)1971. *Microbial Control of Insects and Mites*. Academic Press, London.

De Bach, P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, New York.

Dhaliwal, G.S. and Arora, R. 2001. *Integrated Pest Management: Concepts and Approaches*. Kalyani Publ., New Delhi.

Gautam, R.D. 2008. *Biological Pest Suppression*. Westville Publishing House, Delhi, 304p.

Gerson, H. and Smiley, R.L. 1990. *Acarine Biocontrol Agents-An Illustrated Key and Manual*. Chapman & Hall, New York.

Huffaker, C.B. and Messenger, P.S. 1976. *Theory and Practices of biological Control*. Academic Press, London.

Saxena, A.B. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.

Van Driesche and Bellows, T.S. Jr. 1996. *Biological Control*. Chapman & Hall, New Delhi.

## ENT 506 PRINCIPLES OF INSECT ECOLOGY

(2L+1P) II

### Objective

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

### Theory

#### UNIT I

History of ecology and its basic concepts; habitat and niche, food chain; ecological succession; population theories, Hopkin's bioclimatic law, phase and biotic theory.

#### UNIT II

Ecological and biological indicators; natural balance; biotic potential and environmental resistance; competition; factors affecting insect distribution in time and space; biotic and climatic control; diapause and quiescence, migration and dispersal; tropism and kinas.

### UNIT III

Spatial distribution; sampling; social life and thermoregulation; diversity; global climate change.

### UNIT IV

Modeling population dynamics; life table and key factor analysis; determination of thermal constant and threshold of development, population-weather models, forecasting concept, agro-ecological zoning, and remote sensing.

### Practicals

Types of distributions of organism. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters-measures of central tendencies, Poisson distribution, negative binomial distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's Disc equation assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild. Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of some diversity indices-Shannon's and Avalanche. Index and understanding their associations, and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

### Suggested Readings

- Chapman, J.L. and Reiss, M.J. 2006. *Ecology: Principles & Applications*. 2nd Ed..Cambridge Univ Press, Cambridge.
- Gotelli, N.J. and Ellison, A.M. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc., Sunderland, MA.
- Gupta, R.K. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.
- Krebs, C.J. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings. Publ. Co., New York.
- Magurran, A.E. 1988. *Ecological Diversity and its Measurement*. Princeton Univ. Press, Princeton.
- Price, P.W. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.
- Real, L.A. and Brown, J.H. (Eds.) 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.
- Southwood, T.R.E. and Henderson, P.A. 2000. *Ecological Methods*. 3rd Ed. Methuen & Co. Ltd., London.
- Speight, M.R., Hunto, M.D. and Watt, A.D. 2006. *Ecology of Insect: Concepts and Application*. Elsevier Science Publ., The Netherland.
- Wilson, E.O., William, H. and Bossert, W.H. 1971. *A Primer of Population Biology*. Harvard University, USA.
- Wratten, S.D. and Fry, G.L.A. 1980. *Field and Laboratory Exercise in Ecology*, Arnold, London.

## ENT 507 PRINCIPLES OF INSECT PHYSIOLOGY

(2L+1P) I

### Objective

To impart knowledge to the students on basic aspects of anatomy of different systems, elementary physiology and adaptation of different system of insects according to habits and habitats of the insects.

## Theory

### UNIT I

Scope and importance of insect anatomy and physiology.

### UNIT II

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

### UNIT III

Thermodynamics, physiology of integument, moulting; growth, metamorphosis and diapause.

## Practicals

Dissection of different insects to study comparative anatomical details of different systems; preparation of permanent mounts of internal systems; chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient, preparation and evaluation of various diets, and consumption, utilization and digestion of natural and artificial diets.

## Suggested Readings

Blum, M.S. 1985. *Fundamental of Insect Physiology*, Publ. Witey, New York.

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

Duntson, P.A. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.

Eugelman, F. 1970. *The Physiology of Insect Reproduction*, Publ. Pergamon Press, New York.

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

Nijhout, H.F. 1998. *Insect Hormones*. Publ. Princeton University Press, 41 William Street - N. Jersey.

Patnaik, B.D. 2002. *Physiology of Insects*. Dominant, New Delhi.

Patton, R.L. 1963. *Introductory Insect Physiology*. Publ. Saunders.

Richards, O.W. and Davies, R.G. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Vol. I. *Structure, Physiology and Development*. Chapman & Hall, New York.

Saxena, R.C. and Srivastava, R.C. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.

Wigglesworth, V.B. 1984. *Insect Physiology*. 8th Ed. Chapman & Hall, New York.

## ENT 508 PRINCIPLES OF INSECT TOXICOLOGY

(2L+IP) II

### Objective

To acquaint students with basic concepts of toxicology, types of insecticides and their formulations, plant protection appliances and bioassay techniques.

### Theory

#### UNIT I

Measurement of potency and susceptibility; factors affecting toxicity of insecticides; bio-efficacy; chemical, biological and physical properties of conventional insecticides.

## UNIT II

Laboratory evaluation of insecticides; bioassay techniques and their importance.

## UNIT III

Formulations types, uses, advances and their importance; insect growth regulators and chitin inhibitors.

## UNIT IV

Plant protection appliances; safe storage and handling of pesticides; symptoms of insecticide poisoning and their antidotes; restricting/phasing out of harmful insecticides. Insecticides Act; BIS standards.

### Practicals

To prepare pesticide formulations; measurement of potency and susceptibility; laboratory evaluation of insecticides; plant protection appliances; safe storage and handling of pesticides; symptoms of insecticide poisoning and their antidotes.

### Suggested Readings

Kerkut, G.A. and Gilbert, L.I. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.

Matsumura, F. 1974. *Toxicology of Insecticides*. Vol. 2, Plenum Press, USA.

## ENT 509 HISTORY OF ENTOMOLOGY

(1L+0P) I

### Objective

To acquaint students with history, pioneer entomologists, and development of entomological science.

### Theory

#### UNIT I

Evolution of Insects; earliest records of insect, fossils; genesis of Entomology as a hobby and science—global and national efforts.

#### UNIT II

Entomology in the colonial era; Genesis of Agricultural Entomology & Forest Entomology; contributions of H.M. Lefroy, T. B. Fletcher, H. S. Pruthi, Tashkeer Ahmed, Lionel de Niceville, T. V. R. Iyer, E. S. Narainan, S. Pradhan, N. C. Pant and K.N. Mehrotra and many others.

#### UNIT III

World leaders in entomological research & teaching and their contributions: International level institutes in Entomology like Commonwealth Institute of Entomology, CAB International, British Museum of Natural History, Natural Resources Institute, I.I.I.P.E.; Entomological Societies: USA, Briton, Australia, Canada, India & China; and about leading Journal and Text books in Entomology.

### Suggested Readings

David, B.V. and Kumaraswami, R. 2001. *Elements of Economic Entomology*. Kalyani Publishers, New Delhi.

Pradhan, S. 1969. *Insect Pests of Crops*. National Book Trust, India, 208p.

**Objective**

To enable students to acquire expertise and skill to develop agrochemical formulations with nanoparticles and to acquaint them with nanotechnology

**Theory**

## UNIT I

Introduction: History of nanotechnology – Origin, fundamental concepts, and molecular perspective, Nanomaterials: formation, stability and quality. Application of nanotechnology in agricultural chemicals, bio-pesticides, carriers, surfactants, formulation auxiliaries plant nutrients and related materials

## UNIT II

Effect of bioactive nano-materials on insect pests and beneficial insects. (2 Lectures, Entomology)

## UNIT III

Different types of nano-compounds and their use in the management of plant disease incited by pathogenic fungi, bacteria and viruses with special reference to copper, sulfur etc, Interaction of bioactive nano-materials on plant pathogens including fungi, bacteria, virus etc (3 lectures, Plant Pathology).

## UNIT IV

Nematodes: Plant pathogenic and entomopathogenic nematodes, life cycle, Efficacy of nano chemicals against nematodes, Biotoxins from *Xenorhabdus* and *Photorhabdus*. Identification and quantification of biotoxins effective in nano-doses. (3 lectures, Nematology).

## UNIT V

Microbes: Microbes of agricultural importance. Life cycle: genesis, growth, reproduction, identification and quantification. Nanotechnological application in microbiology (3 lectures, Microbiology)

## UNIT VI

Nanomaterials: size, characterization, formation and stability. Tools for identification and quantitation: Particle size analyzers, nanosizers, scanning microscopes of different types. Development of nano-materials: Bottom-up and top-down approach: Chemical synthesis, sol-gel and emulsion polymerization techniques, wet milling, nano-milling. Stabilization of nanoparticles. Regulations and quality control.

**Practicals**

Identifications, and quantification of agricultural chemicals in conventional and nano formulations, Size determination, Quality of nano-formulations: Cold test, emulsion stability test, and suspensibility tests.

**Suggested Reading**

Allhoff, Fritz, Lin, Patrick (Eds) 2009. *Nanotechnology and Society*, ISBN: 978-1-4020- 6208-7 Springer Publications, UK.

**Objective**

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. International Code of Zoological Nomenclature. Ethics and procedure for taxonomic publications.

**Theory**

## UNIT I

Principles and application of zoological nomenclature; paleontology and phylogeny, species concept and speciation; taxonomic publications.

## UNIT II

Identification keys, description of new taxa; taxonomic characters, numerical taxonomy; cladistics and phenetics.

## UNIT III

Molecular systematic; current trends in insect classification.

## UNIT IV

Taxonomic collections and curation; institutions of importance in biosystematics; status of biosystematics in India.

**Practicals**

Measurement of insects and their parts; Drawing of insects and their parts- preparation of illustrations; Microphotography of insects; Image analysis; Application of ICZN; Preparation and use of diagnostic keys; Morphometrics of insects-statistical procedures; Numerical taxonomy; Taxonomic publications-preparation of publications.

**Suggested Readings**

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

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

Mayr, R. 1971. *Principles of Systematic Zoology*. Tata McGraw-Hill, New Delhi.

Quicke, D.L.J. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie, London.

**Objective**

To teach the students about various microbes that are pathogenic to insects, factors that affect their virulence, provide hands-on training in identification, isolation, culturing various pathogens and assessing pathogenicity.

**Theory**

## UNIT I

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

## UNIT II

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

## UNIT II

Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens (Safety and registration of microbial pesticides).

## UNIT IV

Mammalian toxicity and safety of insect pathogens. Safe use of insect pathogens in integrated management of insect pests.

## UNIT V

Biopesticides formulations, commercial production and economics.

### Practicals

Laboratory practice, introduction to the microscope, aseptic techniques, preparation of microbiological media, Culturing and isolation techniques of insect pathogens, smear preparation, Bacteria, gram's staining, spore staining, Spore counting. Isolation of Bacteria from soil/diseased larvae, isolation of genomic DNA from *Bt* isolates, PCR analysis of *Cry* Genes of *Bacillus thuringiensis* isolates, resolving PCR product on agarose gel electrophoresis, enumeration of NPV using a standard haemocytometer, production of nuclear polyhedrosis, extraction of POBs of NPV, bioassay with NPV, bioassay with *Bt*, isolation of Fungus from diseased insect, preparation of media for mass culture of fungi.

### Suggested Readings

- Burges, H.D. and Hussey, N.W. (Eds.). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
- Burges, H.D. 1981. *Microbial Control of Pests and Plant Diseases*. Academic Press, New York. 949 pp.
- Tanada, Y. and Kaya, H.K. 1992. *Insect Pathology*. Academic Press, San Diego. 666 pp.
- Lacey, L.L. (Ed.) 1997. *Manual of Techniques in Insect Pathology*. Academic Press. 409pp.
- Drion, G., Boucias and Jacquelyn, C.P. 2004. *Principles of Insect Pathology*. Springer Netherland. 235 pp.
- De Bach, P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, New York.
- Boucias, D.G. and Jacquelyn, C.P. 2004. *Principles of Insect Pathology*. Publisher: Springer Netherland. 235 pp.
- Gautam, R.D. 2008. *Biological Pest Suppression*. Westville Publishing House, Delhi. 304p.
- Stock, S.P., Vandenberg, I., Glazer and Boemare, N. (Eds). 2009. *Insect Pathogens: Molecular Approaches and Techniques*. CABI, Oxin, UK.

## ENT 602 ADVANCES IN BIOLOGICAL CONTROL

(2L+1P) II

### Objective

To appraise the students with advanced techniques in handling of different bioagents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.

## Theory

### UNIT I

Scopes of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents *vis-a-vis* target pest populations.

### UNIT II

Mass culturing techniques, immature stages of parasitic and predatory insects, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

### UNIT III

National and international guidelines on natural enemy introduction; success stories of classical biological control, scope of fortuitous biological control due to liberalization in global trade in agriculture; international standards for testing side effects of pesticides on natural enemies; quality control parameters of parasitoid and predators, status of commercialization and field use of parasitoid and predators of important insect pests of crops, and beneficial insects and weeds.

### UNIT IV

Colonization, techniques of release of natural enemies; recovery evaluation, conservation and augmentation of natural enemies; survivorship analysis and ecological manipulations; large-scale production of biocontrol agents, bankable project preparation.

### UNIT V

Scope of genetically engineered microbes and parasitoids in biological control, and genetics of ideal traits in biocontrol agents for introgression and for progeny selections breeding techniques of biocontrol agents.

## Practicals

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various biocontrol agents, performance of efficiency analyses on target pests, project document preparation for establishing a viable mass production unit/insectary.

## Suggested Readings

- Burges, H.D. and Hussey, N.W. (Eds.). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
- Coppel, H.C. and James, W.M. 1977. *Biological Insect Pest Suppression*. Springer Verlag, Berlin.
- De Bach, P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, London.
- Dhaliwal, G.S. and Koul, O. 2007. *Biopesticides and Pest Management*. Kalyani Publ, New Delhi.
- Gautam, R.D. 2008. *Biological Pest Suppression*. Westville Publishing House, Delhi. 304 p.
- Gerson, H. and Smiley, R.L. 1990. *Acarine Biocontrol Agents-An Illustrated Key and Manual*. Chapman & Hall, New York.
- Huffakar, C.B. and Messenger, P.S. 1976. *Theory and Practices of Biological Control*. Academic Press, London.



**Objective**

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, and their integrated management.

**Theory**

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage, and management of insect pests of various crops.

## UNIT I

Fruit Crops - Mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

## UNIT II

Vegetable crops - Tomato, potato, radish, carrot, beetroot, cole crops, french beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables, etc.

## UNIT III

Plantation crops - Coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.

## UNIT IV

Spices and Condiments - pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetle vine, etc.

## UNIT V

Ornamental, medicinal and aromatic plants and their pests in polyhouses/protected cultivation.

**Practicals**

Collection and identification of important pests and their natural enemies on different crops, study of life history of important insect pests and non-insect pests.

**Suggested Readings**

- Atwal, A.S. and Dhaliwal, G.S. 2002. *Agricultural Pests of South Asia and Their Management*. Kalyani Publ., New Delhi.
- Butani, D.K. and Jotwani, M.G. 1984. *Insects and Vegetables*. Periodical Expert Book Agency, New Delhi.
- Srivastava, R.P. 1997. *Mango Insect Pest Management*. International Book Distt., Dehra Dun.
- Verma, L.R., Verma, A.K. and Goutham, D.C. 2004. *Pest Management in Horticulture Crops: Principles and Practices*. Asiatech Publ., New Delhi.

**Objective**

To familiarize the students with types, basis, mechanisms and genetics of resistance in plants to insects and role of plant resistance in pest management. nutritional physiology and their application in entomology.

## Theory

### UNIT I

History and importance of resistance, principles, classification, components, types and mechanisms of resistance.

### UNIT II

Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

### UNIT III

Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance; induced and acquired 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. Role of biotechnology in plant resistance to insects.

### UNIT VI

Insect nutrition - role of vitamins, proteins amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular micro-organisms and their role in physiology, artificial diets.

## Practicals

Screening techniques for measuring resistance, measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

## Suggested Readings

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

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

Maxwell, F.G. and Jennings, P.R. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons, New York.

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

Panda, N. and Khush, G.S. 1995. *Plant Resistance to Insects*. CABI, Oxon, UK.

Smith, C.M. 2005. *Plant Resistance to Arthropods-Molecular and Conventional Approaches*. Springer, Berlin.

Smith, C.M. 1998. *Plant resistance to insects*. CRC Press

## ENT 605 ADVANCES IN INSECT TOXICOLOGY

(2L+1P) III

### Objective

To acquaint students with advances in toxicology, insecticide resistance and pesticide residues.

## Theory

### UNIT I

Pesticides industry in India-commercial aspects; effect of insecticides on insects at population level.

### UNIT II

Insecticide resistance; detection, monitoring and management; synergism, antagonism and potentiation; ecotoxicology and biomagnification.

### UNIT III

Botanical insecticides, synthetic pyrethroids, neonicotinoids, ecdysone, agonist, avermectins and novel group of insecticides.

### UNIT IV

Pesticide residues in commodities and their decontamination; Codex Alimentarius" considerations.

## Practicals

Determination of pesticide residues and decontamination; monitoring and detection of insecticide resistance; synergists; joint toxicity; analysis of biomagnification; and study of antifeedant activity of plant products.

## Suggested Readings

Kerkut, G.A. and Gilbert, L.I. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.

Matsumura, F. 1974. *Toxicology of Insecticides*. Vol. 2, Plenum Press, USA.

## ENT 606 INSECT BIOCHEMISTRY

(2L+1P) III

## Objective

To acquaint students with metabolic specializations in insects in relation to carbohydrates, lipids, amino acids and protein; biosynthesis and mode of action of insect juvenile hormones and ecdysones.

## Theory

### UNIT I

Metabolic specializations in insects in relation to carbohydrates, lipids, amino acids and proteins; role of trehalose and glycogen in energy production.

### UNIT II

Insect lipids and their metabolism during flight, diapause and reproduction; biochemistry of tyrosine, tryptophan and proline metabolism in insects.

### UNIT III

Biosynthesis, mode of action and metabolism of insect juvenile hormones and ecdysones; pheromone biosynthesis and regulation of release; insect neuropeptides and special emphasis on PTTH, adipokinetic hormone, proctolin and bursicon; insect specific proteins.

## Practicals

Estimation of carbohydrates, lipids, amino acids and protein, JH, ecdysone etc. in insect haemolymph. To study pheromone biosynthesis and regulation of neuropeptides, adipokinetic hormone, proctolin and bursicon.

### **Suggested Readings**

- Kerkut, G.A. and Gilbert, L.I. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, New York.
- Nijhout, H.F. 1998. *Insect Hormones*. Publ. Princeton University Press, 41 William Street, N. Jersey.
- Wigglesworth, V.B. 1984. *Insect Physiology*. 8th Ed. Chapman & Hall, New York.

### **ENT 607 BIOCHEMISTRY OF INSECTICIDE ACTION**

**(2L+1P) III**

#### **Objective**

To impart knowledge to students on biochemical and biophysical targets in the nervous system of insects and non-target organisms; structure-activity relationships and mode of action of insecticides; and basic aspects of insecticide metabolizing enzymes.

#### **Theory**

##### UNIT I

Biochemical and biophysical targets in the nervous system of insects and non-target organisms; molecular targets in the neuroendocrine, integument, gut and respiratory systems.

##### UNIT II

Structure-activity relationships and mode of action of insecticides at the molecular level especially of carbamates, organo phosphates, nicotinoids, pyrethroids and recently introduced compounds.

##### UNIT III

Basic aspects of insecticide metabolizing enzymes, metabolism of insecticides in insects and non-target organisms; molecular basis of insecticide selectivity.

#### **Practicals**

To study molecular targets in the neuroendocrine, integument, gut and respiratory systems; mode of action of insecticides at the molecular level; and metabolism of insecticides in insects and non-target organisms.

### **Suggested Readings**

- Kerkut, G.A. and Gilbert, L.I. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.

### **ENT 608 ADVANCES IN INSECT PHYSIOLOGY**

**(2L+1P) II**

#### **Objective**

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones and mechanism of polymorphism, diapause, migration, etc.

#### **Theory**

##### UNIT I

Ultra structure, physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, and types of sclerotization.

## UNIT II

Digestive enzymes, digestive physiology in phytophagous insects, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development, physiology of excretion and osmoregulation, water conservation mechanisms. Evolution of digestive system with food habits and insect habitats.

## UNIT III

Detailed physiology of nervous system ultra structure of nerve and glial cell. Advances in physiology of neuro-endocrine system. Adaptation of insects to various ecosystem transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

## UNIT IV

Endocrine system and insect hormones, physiology of insect growth and development-metamorphosis, polyphenism and diapause. Energetics of muscle contractions. Hormonal control of flight and migration.

### Practicals

To estimate chitin in insect cuticle; study digestive enzymes in phytophagous, mycetomes; to understand physiology of nervous system, endocrine system, defence mechanisms, diapause, polyphenism, frequency of wing beat, abrasion of wax layer of cuticle, food utilization indices, feeding stimulants, dissection of insect brain and associated structures, study of neurosecretory cells, response of heart beat towards test solutions, etc.

### Suggested Readings

- Hedin, P.A. 1983. *Plant Resistance to Insects*. Publ. American Chemical Society, USA.
- Kerkut, G.A. and Gilbert, L.I. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.
- Muraleedharan, K. 1997. *Recent Advances in Insect Endocrinology*. Assoc. for Advancement of Entomology, Trivandrum, Kerala.
- Nation, J.L. 2002. *Insect Physiology and Biochemistry*. CRC Press-Boca Raton, London, New York-Washington DC.
- Smith, C.M. 1998 *Plant Resistance to Insects*. Publ. CRC Press.
- Tauber, M.J., Tauber, C.A. and Masaki, S. 1986. *Seasonal Adaptations of Insects*. Publ. Oxford University Press, INC. (Advanced Insect Physiology)

## ENT 609 RECENT TRENDS IN ENTOMOLOGY

(3L+0P) III

### Objective

To impart knowledge to students on recent developments in entomological research, extension and education.

### Theory

#### UNIT I

Current topics in biosystematics, molecular and numerical approaches; DNA barcodes and biological names register; insect biodiversity and prospects for genetic transformation.

## UNIT II

Chemical Ecology of agriculturally important insect pests; tri-trophic interactions; recombinant insect viruses in insect control; insect behavioural and morphological defenses against parasitoids; perception of sound and light by insect and their applications.

## UNIT III

Ecological side effects of biological control. *Bt* crystal proteins and their mode of action; *Cry* genes in developing insect resistant transgenic crops.

## UNIT IV

Advances in insecticide evaluation; ion channels as targets for insecticides cholinergic, octopamine and GABA receptors.

## UNIT V

Recent advances in reproductive biology and endocrinology of insects. Reproductive parasitism and role of *Wolbachia*; transgenic insects; insect tissue culture; recent developments in sterile insect release programmes; insect gut protease and amylase inhibitors and lectins-their role in transgenic technology.

## UNIT VI

Computer aided decision making and modeling; system approach in agro-ecosystem; remote sensing.

## UNIT VII

Quarantine entomology; forensic entomology; urban entomology. International Standards for Phyto-sanitary Measures (ISPM's).

### Suggested Readings

Burges, H.D. and Hussey, N.W. (Eds.) 1971. *Microbial Control of Insects and Mites*. Academic Press, London.

Coppel, H.C. and James, W.M. 1977. *Biological Insect Pest Suppression*. Springer Verlag, Berlin.

De Bach, P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, London.

Dhaliwal, G.S. and Koul, O. 2007. *Biopesticides and Pest Management*. Kalyani Publ, New Delhi.

Gautam, R.D. 2008. *Biological Pest Suppression*. Westville Publishing House, Delhi. 304 p.

Kerkut, G.A. and Gilbert, L.I. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.

Maxwell, F.G. and Jennings, P.R. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons, New York.

### ENT 610 INSECT GENETICS AND MOLECULAR BIOLOGY

(2L+1P) II

*(Inter disciplinary: Entomology with Genetics / molecular biology)*

#### Objective

To impart knowledge to students on genetics, cytogenetics and molecular basis of insect behaviour.

#### Theory

##### UNIT I

Scope and importance of insect & molecular biology; Relevance to crop pest management.

## UNIT II

Diversity of genetic systems in insects. Sex chromosome in Lepidoptera, Diptera, Coleoptera, Hemiptera and Hymenoptera. Genetic variations in populations; formation of biotype and sibling species; statistical techniques to study genetic variations in populations; parthenogenesis in insects, role of microorganisms such as *Wolbachia*.

## UNIT III

Study of molecular techniques to address fundamental and applied entomological problems, including systematics. Marker-assisted selection of resistant genotypes of plants. Embryo rescue and related techniques in development of plant resistance to insects. Mechanisms of insecticide resistance – historical and contemporary.

## UNIT IV

Insect transgenesis; risk assessment of genetically modified organisms, molecular biology of insect viruses (NPV, GV), genetic modifications in insect viruses for field efficacy; and advances in molecular biology of *Bacillus thuringiensis*.

### Practicals

Study of insect polymorphism and other traits using facilities like PCR, Gel electrophoresis, genetic analysis related to insect resistance, development of insect population for genetic variability, bio-assays for event selection in insect population, study of chromosomes in insects and crossing methods and study of symbionts like *Wolbachia* in natural enemies.

### Selected Readings

Stock, S. Patricia, Vandenberg, J., Glazer, I. and Boemare, N. (ed). 2009. *Insect Pathogens: Molecular Approaches and Techniques*. Published by CABI, Oxon, UK.

## ENT 611 PLANT HEALTH DIAGNOSTICS & MANAGEMENT

(2L+2P) III

*(Multidisciplinary course in collaboration with Plant Pathology and Nematology)*

### Objective

To familiarize the students with different abnormalities caused by insects, pathogens, nematodes, weeds and imbalance use of plant nutrients. Also, develop the confidence in them to handle plant protection problems faced by the farmers/growers.

### Theory

#### UNIT I

Introduction to the plant health clinic: concept, importance, infrastructure, etc. Identification of important beneficial insects (parasitoids, predators, pollinators and others of economic importance). Principles of pest management.

#### UNIT II

Injury caused by different type of insects to the plants by feeding, oviposition, sheltering or any other means.

#### UNIT III

Screening of damaged material for establishing the identity of casual agent *viz.*, insect, microbe, nematode, mites, rodents, vertebrates, competitive plant as well as nutritional or any other physiological disorders.

#### UNIT IV

Important plant parasitic nematodes and their symptoms produced on major field, fruit, ornamental and plantation crops.

#### UNIT V

Damage caused by important nematodes causing root knot, ear-cockle and other diseases in different crops and their management.

#### UNIT VI

Molecular approaches for viral, bacterial and fungal diseases with regards to diagnostics and management.

#### UNIT VII

Symptoms of diseases caused by imbalances in plant nutrients.

#### UNIT VIII

Identification of problematic weeds and their management.

### **Practicals**

Identification of symptoms caused by important insect pests. Preparation of pesticide stock solution and safe handling of agrochemicals. Disease diagnostic kit and related basic facilities. Identification of common diseases. Types of plant parasitic nematodes, demonstration of pathogenicity of root knot nematode on tomato and vegetables, and root knot index calculation. Symptoms of Molya disease and Ear-cockle disease of wheat. Management methods to manage nematode diseases in crop.

### **Suggested Readings**

Nair, MRGK. 1986. *Insect and Mites of Crops in India*. ICAR, New Delhi.

Pradhan, S. 1969. *Insect Pests of Crops*. National Book Trust, India. 208 p.

Regupathy, A.N., Chandramohan, S., Palanisamy and Gunathilagaraj, K. 2003. *A Guide on Crop Pests*. TNAU, Coimbatore. 276 pp.