Visva-Bharati
Palli Siksha Bhavana
Department of Agricultural Entomology

Ref. No. PSB/AEN/Restructured PG Syllabi/2022 02-11-2022

To
The Principal
Palli Siksha Bhavana
Sriniketan

Subject: Submission of the Restructured and Revised PG syllabi as per BSMA guidelines of ICAR

Dear Sir,

Apropos of the above I am submitting herewith a copy of the restructured and revised PG syllabi of M.Sc.(Ag) in Entomology as per BSMA guidelines of ICAR for incorporation of the same from this academic session. The proposal for adoption of this revised syllabus has been duly approved by the honourable BOS members in the BOS meeting held on 28.10.2022. (Proceedings of the BOS meeting is attached herewith).

With regards,

Yours sincerely,

02.11.2022
प्रधान/Head
कृषि कीट विज्ञान विभाग
Department of Agricultural Entomology
पल्ली शिक्षा भवन
Palli Siksha Bhavana

Adoption of Restructured and Revised Syllabi of Post-graduate Programmes as per BSMA guidelines of ICAR for M.Sc. (Ag) in Entomology

Palli Siksha Bhavana,
Visva-Bharati, Sriniketan

Approved in the BOS meeting of the Dept. of Agricultural Entomology on 28.10.2022
Approved in the Institute Board , PSB vide no. PSB/9-S/150/2022-23 dt. 25.11.2022
Approved by the Academic Council subject to ratification videNo. Aca/AC/1395/2022-23 dt. 05.12.2022

SYLLABUS OF M.SC.(AG) IN ENTOMOLOGY

ORGANIZATION OF COURSE CONTENTS
&
CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into series: 500-series courses pertain to Master's level and 600 series to Doctoral level.
- Credit seminar for Master's level is designated by code no. 591
- Similarly 599 code has been given for Master's research.

Master of Science (Agriculture) in Entomology:

1. A candidate completing a minimum of 70 credits (Major courses-20; Minor courses-08; Supporting courses- 06; Compulsory common courses- 05, Master's Seminar-01 and Master's Research - 30) is eligible to earn the degree
2. In addition to above a candidate may be permitted to opt for a required number of credits from optional major courses and minor or supporting courses as suggested by the Chairman of Advisory committee.

The total credit requirements for obtaining Master's Degree in Entomology are:

Particulars	Minimum Credits
i) Course Work	
Major Courses	**20**
Minor courses	**08**
Supporting courses	**06**
Common courses	**05**
Seminar	**01**
ii) Thesis Research	**30**
Total	**70**

Restructured and revised syllabi of PG Courses offered in the Department of Agricultural Entomology

Course Code	Course title	Credit hours
ENT-501*	Insect morphology	3(2+1)
ENT -502*	Insect anatomy & Physiology	3(2+1)
ENT -503*	Insect taxonomy	3(2+1)
ENT -504*	Insect Ecology	3(2+1)
ENT -505*	Biological control of Insect Pests and Weeds	3(2+1)
ENT -506*	Toxicology of insecticides	3(2+1)
ENT -507	Host Plant Resistance	2(1+1)
ENT -508*	Concepts of Integrated Pest Management	2(2+0)
ENT -509	Pest of Field crops	3(2+1)
ENT–510*	Pest of Horticultural & Plantation crops	3(2+1)
ENT -511	Post Harvest Entomology	2(1+1)
ENT -512	Insect-vectors of plant pathogens	2(1+1)
ENT -513	Principles of Acarology	2(1+1)
ENT -514	Vertebrate Pest Management	2(1+1)
ENT -515	Techniques in Plant Protection	1(0+1)
ENT - 516	Apiculture	3(2+1)
ENT - 517	Sericulture	3(2+1)
ENT -518	Lac Culture	3(2+1)
ENT -519	Molecular Approaches in Entomology	3(2+1)
ENT -520	Plant Quarantine, Bio-safety and Bio-security	2(2+0)
ENT -521	Edible and Therapeutic Insects	2(1+1)
ENT -522	Medical and Veterinary Entomology	2(1+1)
ENT -523	Forest Entomology	2(1+1)
ENT -591*	Master's Seminar	1(0+1)
ENT -599*	Master's Research Thesis (Compulsory)	30(0+30)

*Compulsory Major Courses for M.Sc. (Ag.) in Entomology

A. Semester wise Course Distribution for pursuing M.Sc.(Ag) in Entomology,

Semester wise offered Major Courses *

Semester	Course Code	Course title	Credit hours
	SEMESTER-I		
I	ENT-501*	Insect morphology	3(2+1)
	ENT -502*	Insect anatomy & Physiology	3(2+1)
	ENT -507	Host Plant Resistance	2(1+1)
	ENT -508*	Concepts of Integrated Pest Management	2(2+0)
	ENT -511	Post Harvest Entomology	2(1+1)
	ENT -512	Insect-vectors of plant pathogens	2(1+1)
II	**SEMESTER-II**		
	ENT -503*	Insect taxonomy	3(2+1)
	ENT -504*	Insect Ecology	3(2+1)
	ENT -509	Pest of Field crops	3(2+1)
	ENT -513	Principles of Acarology	2(1+1)
	ENT -514	Vertebrate Pest Management	2(1+1)
	ENT -515	Techniques in Plant Protection	1(0+1)
	SEMESTER-III		
III	ENT - 505*	Biological control of Insect Pests and Weeds	3(2+1)
	ENT -506*	Toxicology of insecticides	3(2+1)
	ENT – 510*	Pest of Horticultural & Plantation crops	3(2+1)
	ENT - 516	Apiculture	3(2+1)
	ENT - 517	Sericulture	3(2+1)
	ENT -518	Lac Culture	3(2+1)
IV	**SEMESTER-IV**		
	ENT -519	Molecular Approaches in Entomology	3(2+1)
	ENT -520	Plant Quarantine, Bio-safety and Bio-security	2(2+0)
	ENT -521	Edible and Therapeutic Insects	2(1+1)
	ENT -522	Medical and Veterinary Entomology	2(1+1)
	ENT -523	Forest Entomology	2(1+1)
	ENT -591*	Master's Seminar	1(0+1)
	ENT -599*	Master's Research Thesis (Compulsory)	30 (0+30)

***Courses are compulsory major for acquiring the degree of M.Sc.(Ag) in Entomology.**

Course Contents
M.Sc. (Ag) in Entomology

1. Course Title: Insect Morphology; Code: ENT 501, Credit Hours: 3 (2+1)

Theory

Aim of the course

To acquaint the students with the external morphology of the insect's body and the functioning of various body parts

Unit I

EXternal Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

Head- Origin, **s**tructure 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 forensicentomology.

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 hemi-metabola 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;

Learning outcome

Students are expected to have a complete understanding of the comparative morphology of the external features of insects that can be utilized in taxonomy, ecology and applied entomology.

2. Course Title: Insect Anatomy and Physiology; Code: ENT- 502 , Credit Hours: 3 (2+1)

Theory

Aim of the course

To impart knowledge about the anatomy and physiology of insect body systems; nutritional physiology; and their applications in entomology

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 and 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 variousdiets;
- Consumption, utilization and digestion of natural and artificial diets.

Learning outcome

Students are expected to have a thorough understanding of insect growth and development, physiology of exoskeleton, endoskeleton and different organ systems; action and role of hormones, pheromones, physiology of nutrition and its application

3. Course Title: Insect Taxonomy; Code: ENT- 503 , Credit Hours: 3 (2+1)

Theory

Aim of the course

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

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 of different orders.

Learning outcome

Students are expected to know the evolution of arthropods, especially insects and other hexapods, and their hierarchical classification.
Acquire working skills for collecting, mounting, and preserving insects
Understand the basic concepts of taxonomic hierarchy, identification, taxonomic characters, variations, taxonomic keys and preparation of taxonomic papers
Identify insects of economic importance up to family levels, taking up the insect orders of agriculture and veterinary importance

4. Course Title: Insect Ecology; Code: ENT- 504 , Credit Hours: 3 (2+1)

Theory

Aim of the course

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.

Unit I

History and definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance *vs* Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

Unit II

Basic concepts of abundance- Model *vs* Real world. Population growth basic models- EXponential *vs* Logistic models. Discrete *vs* Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) – aestivation, hibernation.

Unit III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basicfactors 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 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 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.

Learning outcome

The students are expected to be well versed with the basic concepts of ecology, ecological succession, population ecology, community ecology, nutritional ecology and different insect-ecosystem interactions. Quantification of insect diversity and abundance, life table analyses, predator- prey and host-parasitoid relations, functional and numerical responses, niche breadth and overlap. They also develop a skill to develop eco-friendly and sustainable pest management.

5. Course Title: Biological Control of Insect Pests and Weeds; Code: ENT- 505, Credit Hours: 3 (2+1)

Theory

Aim of the course

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.

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, egg- larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds;
- Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Learning outcome

Students are expected to have a good understanding on the role of natural enemies in managing pest populations below those causing economic damage. Develop skill on mass

production of quality bio-agents and their optimal use in IPM. This will generate employment in different Govt. sectors, MNCs & NGOs

6. Course Title: Toxicology of Insecticides; Code: ENT- 506 , Credit Hours: 3 (2+1)

Theory

Aim of the course

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**.**

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 of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, 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.

Learning outcome

Students are expected understand the concept of toxicity, bio-efficacy, insecticide formulations, modes of action of insecticides, estimation of insecticide residues and have significant know-how about the functioning of various types of spray equipments. This will generate employment in different Govt. sectors, MNCs & NGOs

7. Course Title: Host Plant Resistance; Code: ENT- 507, Credit Hours: 2 (1+1)

Theory

Aim of the course

To orient the students with host plant resistance.

Unit I

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

Unit II

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

Unit III

Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance – acquired and induced systemic resistance.

Unit IV

Factors affecting plant resistance including biotypes and measures to combat them.

Unit V

Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

Unit VI

Role of biotechnology in plant resistance to insects.

Practical

- Screening techniques for measuring resistance;
- Measurement of plant characters and working out their correlations with plant resistance;
- Testing of resistance in important crops;
- Bioassay of plant extracts of susceptible/ resistant varieties;
- Demonstration of antibiosis, tolerance and antixenosis.

Learning outcome

Students are expected to acquire a thorough knowledge of the types and basis of mechanisms involved in host plant resistance, screening techniques to measure resistance and insect resistance breeding.

8. Course Title: Concepts of Integrated Pest Management: Code: ENT-508, Credit Hours: 2 (2+0)

Theory

Aim of the course

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

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; semiochemicals, 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 organic farming; 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.

Learning outcome

Students are expected to have significant knowledge of IPM concepts, estimation of losses due to insect pests, computation of ETL, EIL and should be able to take management decisions.

9. Course Title: Pests of Field Crops; Code: ENT- 509, Credit Hours: 3(2+1)

Theory

Aim of the course

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

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.

Learning outcome

Students are expected to acquire knowledge of insect pests of field crops, their nature of damage, life history traits and effective management.

10. Course Title: Pests of Horticultural and Plantation Crops; Code: ENT- 510, Credit Hours: 3(2+1)

Theory

Aim of the course

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

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/ protectedcultivation.

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.

Learning outcome

Students are eXpected to acquire knowledge of insect pests of horticultural, medicinal and plantation crops, their nature of damage, life history traits and effective management.

11. Course Title: Post Harvest Entomology; Code: ENT- 511, Credit Hours: 2(1+1)

Theory

Aim of the course

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.

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 andextent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

Unit III

Ecology of insect pests of stored commodities/ grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

Unit IV

Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/ receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control- prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. 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).

Learning outcome

Students are expected to acquire knowledge of pestiferous insects, mites, rats and birds affecting stored produce, their nature of damage, life history traits and effective management. Detection of insect infestation and familiarization with different storage structures. Learning preventive and curative measures to manage infestation in storage houses. Also develop a skill to get employment in various Central ware houses and different MNCs.

12. Course Title: Insect Vectors of Plant Pathogens; Code: ENT- 512, Credit Hours: 2(1+1)

Theory

Aim of the course

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.

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.

Learning outcome

Students are expected to be well versed with insect vectors of plant pathogens, acquire

knowledge on disease transmission and vector management techniques. also develop a skill to get employment in various Govt. quarantine sectors and MNCs.

13. Course Title: Principles of Acarology; Code: ENT- 513, Credit Hours: 2(1+1)

Theory

Aim of the course

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.

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.

Learning outcome

Students are expected to identify mites up to family level. Acquire knowledge of mite pests of cultivated crops, their nature of damage, life history traits and develop skill in effective management. Also generate employment in various Govt. sectors and MNCs.

14. Course Title: Vertebrate Pest Management; Code: ENT- 514, Credit Hours: 2(1+1)

Theory

Aim of the course

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

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.

Learning outcome

Students are eXpected to be well versed with vertebrate pest diversity, their nature of damage, life history traits, behaviour and effective management. They also develop a skill to get employment in various Govt. sectors and MNCs.

15. Course Title: Techniques in Plant Protection; Code: ENT- 515, Credit Hours: 1(0+1)

Practical

Aim of the course

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

- 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.

Learning outcome

Students are expected to have a good knowledge of different plant protection equipments and techniques related to pest forecasting. They also develop a skill to get employment in various Govt. sectors and MNCs.

16. Course Title: Apiculture; Code: ENT- 516, Credit Hours: 3(2+1)

Theory

Aim of the course

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

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 honeybees;
- 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.

Learning outcome

Students are expected to have a comprehensive knowledge of bee biology, physiology and bee keeping/ apiculture. With practical training it is expected that students will develop entrepreneurial skillsfor apiculture and ultimately employment generation.

17. Course Title: Sericulture; Code: ENT- 517, Credit Hours: 3(2+1)

Theory

Aim of the Course

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

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.

Learning outcome

Students taking up sericulture are expected to have a thorough knowledge of silkworm morphology, races, biology, and develop the skill for rearing for silk production. They should be well versed with the pests and diseases of silkworm and their management. With practical training it is expected that students develop entrepreneurial skills for sericulture or link up with industries to sell cocoons for silk production or guide farmers engaged in silk worm rearing/ sericulture as well as generate employment for the landless labourers.

18. Course Title: Lac Culture; Code: ENT- 518, Credit Hours: 3(2+1)

Theory

Aim of the course

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.

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.

Learning outcome

The students are expected to have good knowledge of lac host trees and their maintenance for lac production. It is expected that they should acquire the most suitable techniques for lac production with a good knowledge about diseases and natural enemies of the lac insect. After completion of the course it is expected that it would provide wider scope for location-specific self employment,

skill and entrepreneurship development as envisaged in the National Educational Policy towards enhancement of farmer's income

19. Course Title: Molecular Approaches in Entomology; Code: ENT- 519, Credit Hours: 3(2+1)

Theory

Aim of the course

To acquaint students the latest techniques used in molecular biology.

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, Plant- derived 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 insect- pests, 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 sequencewith sequences already available in GenBank;
- Isolation of host plant proteins, SDS-PAGE of the isolated proteins.

Learning outcome

The students are expected to develop skill with the basic techniques used in molecular biology and employment generation in Bioinformatics centers.

20. Course Title: Plant Quarantine, Bio-safety and Bio-security; Code: ENT- 520, Credit Hours: 2(2+0)

Theory

Aim of the course

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 andbiosecurity.

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.

Learning outcome

Students offering this course are expected to have a good knowledge of the rules and regulations of Plant Quarantine, WTO regulations, GAP, Sanitary and Phytosanitary measures. Have immense scope of employment in different Quarantine centres.

21. Course Title: Edible and Therapeutic Insects; Code: ENT- 521, Credit Hours: 2(1+1)

Theory

Aim of the course

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

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.

Learning outcome

Students are expected to be aware of insects for edible and therapeutic use; their nutritional composition. They should know the techniques of farming and processing insects for human and animal consumption. This creates an immense scope for entrepreneurship development.

22. Course Title: Medical and Veterinary Entomology; Code: ENT- 522, Credit Hours: 2(1+1)

Theory

Aim of the course

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.

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.

Learning outcome

Students are expected to identify the arthropods of medical and veterinary importance; identify the diseases transmitted by these arthropod vectors and suggest management options. I also generate employment in the arena of contagious disease management.

23. Course Title: Forest Entomology; Code: ENT- 523, Credit Hours: 2(1+1)

Theory

Aim of the course

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.

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.

Learning outcome

Students are expected to acquire knowledge of insect pests of forest nurseries, forests and plantations, their nature of damage, life history traits and effective management. Likewise, students are expected to have a thorough knowledge of pestiferous insects of stored timber, hide and other forest produce. Also generate employment in Timber industry.

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