



Kamla Nehru Institute of Physical & Social Sciences, Sultanpur (UP)-228118

(An Autonomous Institute)

'NAAC - 'A' Grade'

Structure of syllabus for the program

B.Sc. (AG) & M.Sc. (AG) : Subject- Entomology


Syllabus developed/proposed by

S.No.	Name	Designation	Department	College/University/Address
1.	Dr. Naveen Vikram Singh	Convenor	Entomology	K.N.I.P.S.S., Sultanpur
2.	Dr. Bal Mukund Pandey	Member	Entomology	K.N.I.P.S.S., Sultanpur
3.	Dr. Rahul	Member	Entomology	K.N.I.P.S.S., Sultanpur
4.	Dr. Umesh Chandra	Member (Nominee Academic Council)	Entomology	A.N.D.U.A.&T., Kumarganj, Ayodhya
5.	Dr. Akhilesh Tripathi	Member (Nominee Academic Council)	Entomology	Kulbhaskar Ashram P.G. College, Prayagraj
6.	Prof. Manoj Kumar Tripathi	Member (Nominee V.C., Dr. RMLAU)	Entomology	Principal, F.G. College, Raibareilly
7.	Sri Baldev Singh (Industrialist)	Member (Nominated Principal)	NA	Punjabi Colony, Kurwara Naka, Sultanpur
8.	Sri Jagjeet Singh (Ex-student)	Member (Nominated Principal)	NA	Near Vijay Delux, Laldiggi, Sultanpur

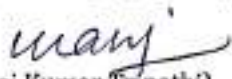
As per syllabus development guidelines of Higher Education for UG & PG Course-


(Dr. Bal Mukund Pandey)
Member

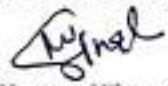
K.N.I.P.S.S., Sultanpur



(Dr. Umesh Chandra)

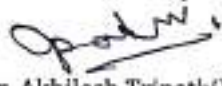
Member (Nominee Academic Council)
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UNDER GRADUATE CURRICULAR & SYLLABUS
B.Sc. (Hons.) Agriculture
Semester System as per ICAR Vth Deans Committee Report
ENTOMOLOGY

Sr. No.	Course code	semester	Name of papers	Credit hrs.
1	AG-203	II	Fundamentals of Entomology-I (Insect Morphology and Taxonomy)	3 (2+1)
2	AG-312	III	Fundamentals of Entomology-II (Insect Ecology and concept of IPM)	2 (1+1)
3	AG-503	V	Pests of Field crops & Stored Grain and their Management	3 (2+1)
4	AG-608	VI	Beneficial insects and Pest of Horticultural Crops and their Management	3 (2+1)
5		VIII	Commercial Beekeeping	0+10

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1. FUNDAMENTALS OF ENTOMOLOGY-I

3(2+1) AG-203

(INSECT MORPHOLOGY & TAXONOMY)

Theory

Classification of phylum Arthropoda upto classes. Relationship of class Insecta with other classes of Arthropoda. Morphology: Structure and functions of insect cuticle and moulting. Body segmentation. Structure of Head, thorax and abdomen. Structure and modifications of insect antennae, mouth parts, legs, wing venation, modifications and wing coupling apparatus. Structure of male and female genital organs. Metamorphosis and diapause in insects. Types of larvae and pupae. Structure and functions of digestive, circulatory, excretory, respiratory, nervous, secretory (Endocrine) and reproductive systems in insects. Types of reproduction in insects. Major sensory organs like simple and compound eyes and chemoreceptors. Systematics: Taxonomy - importance, history and development and binomial nomenclature. Definitions of Biotype, Sub-species, Species, Genus, Family and Order. Classification of class Insecta upto Orders, basic groups of present day insects with special emphasis to orders and families of Agricultural importance like Orthoptera: Acrididae. Dictyoptera: Mantidae, Odonata: Isoptera: Termitidae; Thysanoptera: Thripidae; Hemiptera: Pentatomidae, Coreidae, Cimicidae, Pyrrhocoridae, Lygaeidae, Cicadellidae, Delphacidae, Aphididae, Coccidae, Lophophidae, Aleocharidae, Pseudococcidae; Neuroptera: Chrysopidae; Lepidoptera: Pieridae, Papilionidae, Noctuidae, Sphingidae, Pyralidae, Gelechiidae, Arctiidae, Saturniidae, Bombycidae; Coleoptera: Coccinellidae, Chrysomelidae, Cerambycidae, Curculionidae, Bruchidae, Scarabaeidae; Hymenoptera: Fenthridinidae, Apidae, Trichogrammatidae, Ichneumonidae, Braconidae, Chalcididae; Diptera: Cecidomyiidae, Tachinidae, Agromyziidae, Culicidae, Muscidae, Tephritidae.

Practical

Methods of collection and preservation of insects including immature stages: External features of Grasshopper/Blister beetle: Types of insect antennae, mouthparts and legs; Wing venation, types of wings and wing coupling apparatus. Types of insect larvae and pupae; Dissection of digestive system in insects (Grasshopper); Dissection of male and female reproductive systems in insects (Grasshopper); Study of characters of orders Orthoptera, Dictyoptera, Odonata, Isoptera, Thysanoptera, Hemiptera, Lepidoptera, Neuroptera, Coleoptera, Hymenoptera, Diptera and their families of agricultural importance.

2. FUNDAMENTALS OF ENTOMOLOGY-II

2(1+1) AG-312

(INSECT ECOLOGY & CONCEPTS OF IPM)

Theory

Insect Ecology: Introduction, Environment and its components. Effect of abiotic factors - temperature, moisture, humidity, rainfall, light, atmospheric pressure and air currents. Effect of biotic factors - food competition, natural and environmental resistance.

IPM:

Categories of pests. Concept of IPM, Practices, scope and limitations of IPM. Classification of insecticides, toxicity of insecticides and formulations of insecticides. Chemical control - importance, hazards and limitations. Recent methods of pest control, repellents, anti feed ants, hormones, attractants, gamma radiation. Insecticides Act 1968 - Important provisions. Application techniques of spray fluids. Symptoms of poisoning, first aid and antidotes. Survey, surveillance and forecasting of insect pests. Safety issues of pesticides uses.

Practical

Sampling techniques for estimation of insect population and damage. Insecticides and their formulations. Pesticide appliances and their maintenance.

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3. PESTS OF FIELD CROPS, STORED GRAINS AND THEIR MANAGEMENT

3(2+1) AG-503

Theory

General account on nature and type of damage by following insect pests arthropods pests. Scientific name, order, family, host range, distribution, biology and bionomics. nature of damage, and management of major pests and scientific name, order, family, host range, distribution, nature of damage and control practice other important arthropod pests(mites) of various field crops. Factors affecting losses of stored grain and role of physical, biological, mechanical and chemical factors in deterioration of grain. Insect pests, mites, rodents, birds and microorganisms associated with stored grain and their management. Storage structure and methods of grain storage and fundamental principles of grain store management.

Paddy: *Leptocorisa varicornis*, *Hieroglyphus Spp.*, *Nilaparvata lugens*, *Nephotetix*, *spp.* *Mythimna separata*.

Jowar Maize: *Chilo partellus*, *Atherigona variasocata*, *Scirpophaga excerptalis*, *Chilo infuscatellus*

Sugarcane: *Top borer*, *Pyrilla*, *Early Shoot borer* and *white fly*

Cotton: *Pectinaphora gossypiella*, *Earias Spp*, *Sylepta derogata*, *Dysdercus Spp* *Bemisiatabacz*, *Anrasca bzgutulla*

Oilseeds: *Lipaphis erysimi*, *Athalia proxima* *Rograda Cruciferarum*, *Dasyneura*

Pulses: *Helicoverpa armigera* *Agrotis Spp.*, *Etiella zinckenella*

Pests of Stored Grains: *Sitophilus oryzae*, *Trogoderma granarium*, *Sitotroga cerealella*, *Callosobruchius chinensis*.

Polyphagous pests: *Odontotermes obesus*, *Holotrichia consanguinea*, *Spilosoma obliqua*, *Spodoptera litura*, *Amsacta Spp*

Practical

Identification of different types of damage. Identification and study of life cycle and seasonal history of various insect pests attacking field crops and their produce. Identification of insect pests and Mites associated with stored grain. Determination of insect infestation by different methods. Assessment of losses due to insects. Calculations on the doses of insecticides application technique. Fumigation of grain store & godown. Identification of rodents and rodent control operations in godowns. Identification of birds and bird control operations in godowns. Determination of moisture content of grain. Methods of grain sampling under storage condition. Visit to Indian Storage Management and Research Institute, Hapur and Quality Laboratory, Department of Food., Delhi. Visit to nearest FCI godowns.

4. BENEFICIAL INSECTS and PESTS OF HORTICULTURAL CROPS AND THEIR MANAGEMENT

3 (2+1) AG-608

Theory

Types of silkworm, voltinism and biology of silkworm. Mulberry cultivation, mulberry varieties, methods of harvesting and preservation of leaves. Rearing of mulberry silkworm, rearing appliances, mounting and harvesting of cocoons. Pests and diseases of silkworm, management, and methods of disinfection. Importance of beneficial insects, bee keeping, pollinating plants and their cycle, bee biology, commercial methods of rearing, equipment used and seasonal management. Bee pasturage, bee foraging and communication. Insect pests and diseases of honey bee. Species of lac insect, morphology, biology, host plant and lac production Processing of lac - seed lac, button lac, shellac and lac- products. Identification of major parasitoids and predators commonly used in biological control.

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Practical

Identification of different types of damage. Identification and study of life cycle and seasonal history of various insect pests attacking horticultural crops - vegetable crops, fruit crops, plantation gardens, narcotics, spices & condiments. Visit to orchards and gardens. Mulberry cultivation, mulberry varieties and methods of harvesting and preservation of leaves. Types of silkworm, voltinism and biology and rearing of silkworm and equipment. Honey bee species and castes of bees. Beekeeping appliances and seasonal management. Bee enemies and diseases, Bee pasturage, bee foraging and communication. Species of lac insect, host plant identification. Identification of other important pollinators, weed killers and scavengers. Visits to research and training institutions devoted to sericulture, beekeeping, lac culture and natural enemies.

5. COMMERCIAL BEE KEEPING (ELP)

Evaluation of Experiential Learning Programme

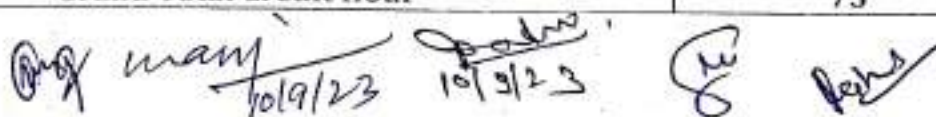
Sr. No.	Parameters	Max. Marks
1	Project Planning and Writing	10
2	Presentation	10
3	Regularity	10
4	Monthly Assessment	10
5	Output delivery	10
6	Technical Skill Development	10
7	Entrepreneurship Skills	10
8	Business networking skills	10
9	Report Writing Skills	10
10	Final Presentation	10
	Total	100

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Department of Entomology

M.Sc. (Ag.) Entomology without Thesis

M.Sc. Ag. 1 st Sem.		
Code No.	Course Title	Credit Hours
ENT-501	Insect Morphology	3(2+1)
ENT-502	Insect Anatomy & Physiology	3(2+1)
ENT-503	Insect Taxonomy	3(1+2)
PL PATH-505	Principles of Plant Pathology (Minor)	3(2+1)
STAT-502	Statistical Method for Applied Sciences	4(3+1)
PGS-501	Library and Information Services	1(0+1)
PGS-502	Technical Writing & Communication Skills	1(0+1)
Total Credit		18
M.Sc. Ag. 2 nd Sem.		
ENT-504	Insect Ecology	3(2+1)
ENT-505	Biological Control of Insect Pest & Weeds	3(2+1)
ENT-506	Toxicology of Insecticides	3(2+1)
PL PATH-517	Diseases of Vegetable and Spices Crops (Minor)	3(2+1)
STAT-511	Experimental Designs	3(2+1)
PGS-503	Intellectual Property & Its Management In Agriculture	1(1+0)
PGS-504	Basic Concept in Laboratory Techniques	1(0+1)
ENT-515	Techniques in Plant Protection	1(0+1)
Total Credit		18
M.Sc. Ag. 3 rd Sem.		
ENT-509	Pests of Field Crops	3(2+1)
ENT-516	Apiculture	3(2+1)
ENT-517	Seri Culture	3(2+1)
ENT-508	Concept of Integrated Pest Management	2(2+0)
PL PATH-515	Diseases of Field and Medicinal Crops (Minor)	3(2+1)
ENT-510	Pests of Horticultural & Plantation Crops	3(2+1)
PGS-505	Agricultural Research, Research Ethics & Rural Development Programme	1(1+0)
Total Credit		18
M.Sc. Ag. 4 th Sem.		
ENT-518	Lac Culture	3(2+1)
ENT-507	Host Plant Resistance	2(1+1)
ENT-511	Post-Harvest Entomology	3(2+1)
ENT-512	Insect Vectors of Plant Pathogen	2(1+1)
ENT-591	Master Seminar	1(0+1)
	Project/Dissertation	10(0+10)
Total Credit		21
Grand Total Credit Hour		75



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Department of Entomology
M.Sc. (Ag.) Entomology with Thesis

M.Sc. Ag., 1 st Semester		
Code No.	Course Title	Credit Hours
ENT-501	Insect Morphology	3(2+1)
ENT-502	Insect Anatomy & Physiology	3(2+1)
ENT-503	Insect Taxonomy	3(1+2)
PL PATH-505	Principles of Plant Pathology (Minor)	3(2+1)
STAT-502	Statistical Method for Applied Sciences	4(3+1)
PGS-501	Library and Information Services	1(0+1)
PGS-502	Technical Writing & Communication Skills	1(0+1)
Total Credit		18
M.Sc. Ag., 2 nd Semester		
ENT-504	Insect Ecology	3(2+1)
ENT-505	Biological Control of Insect Pest & Weeds	3(2+1)
ENT-506	Toxicology of Insecticides	3(2+1)
PL PATH-515	Diseases of Field and Medicinal Crops (Minor)	3(2+1)
STAT-511	Experimental Designs	3(2+1)
PGS-503	Intellectual Property & Its Management In Agriculture	1(1+0)
PGS-504	Basic Concept in Laboratory Techniques	1(0+1)
ENT-599	Research Work	1(0+1)
Total Credit		18
M.Sc. Ag. 3 rd Semester		
ENT-508	Concept of Integrated Pest Management	2(2+0)
ENT-509	Pests of Field Crops	3(2+1)
PL PATH-517	Diseases of Vegetable and Spices Crops (Minor)	3(2+1)
ENT-599	Research Work	9(0+9)
PGS-505	Agricultural Research, Research Ethics & Rural Development Programme	1(1+0)
Total Credit		18
M.Sc. Ag. 4 th Semester		
ENT-591	Master Seminar	1(0+1)
ENT-599	Research Work	15(0+15)
ENT-599	Thesis Writing/Viva-Voce	5(5+0)
Total Credit		21
Grand Total Credit Hour		75

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Entomology Course Content (Major)

ENT 501

INSECT MORPHOLOGY

3(2+1)

Objective

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

Theory

UNIT I

External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites. Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications. Abdomen- Segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development.

UNIT II

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

UNIT III

Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in 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 outcomes

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.

Suggested Reading:

- Chapman, RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.
- Dantson, PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.
- Evans, JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.
- Gillott, C. 1995. *Entomology*, 2nd Ed. Plenum Press, New York, London.
- Gullan, P.J. and Cranston, P.S. 2000. *The Insects, An Outline of Entomology*, 2nd Ed. Blackwell Science, U.K.
- Richards, OW and Davies, RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman and Hall, London.

Original copy by Dr. P. K. Singh
Date: 26/11/2024

- Snodgrass, R.E. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.
- Tembhore, D.B. 2000. *Modern Entomology*, Himalaya Publishing House, Mumbai.
- Chu, H.F. 1992. *How to Know Immature Insects*. William Brown Publication, Iowa.
- Peterson, A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.
- Stehr, F.W. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publication, Iowa.

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Objective

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

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

Practical

Latest analytical techniques for analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination and count of insect haemocytes; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

Learning outcomes

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.

Suggested Reading

- Chapman RF.1998. Insects: Structure and Function. ELBS Ed., London.
- Duntson PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
- Gullan, P.J. and Cranston, P.S. 2000. The Insects: An Outline of Entomology, 2nd Ed. Blackwell Science, U.K.
- Kerkut GA and Gilbert LI. 1985. Comprehensive Insect Physiology, Biochemistry and Pharmacology. Vols. I-XIII. Pergamon Press, New York.
- Patnaik BD. 2002. Physiology of Insects. Dominant Publishers, New Delhi.
- Richards OW and Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Vol. 1. Structure, Physiology and Development. Chapman and Hall, New York.
- Simpson, S.J. 2007. Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.
- Wigglesworth VB.1984. Insect Physiology, 8th Ed. Chapman and Hall, New York.

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Objective

To sensitize the students on the theory and practice of classifying organisms (with special reference to animals) and the rules governing the same. To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects with an emphasis on the practical aspects.

Theory**UNIT I**

History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy v/s homology, parallel v/s convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects- introduction to phylogeny of insects and Classification of Superclass Hexapoda - Classes - Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systematics, 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 Panorpid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

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

Learning outcomes

- 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.

Suggested Reading

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- CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
- Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.
- Gullan, P.J. and Cranston, P.S. 2010. The Insects: An outline of Entomology. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.
- Mayr, E. 1971. Principles of Systematic Zoology. Tata McGraw Hill, New Delhi.
- Richards OW and Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
- Ross III. 1974. Biological Systematics. Addison Wesley Publ. Company.
- Triplehorn CA and Johnson NF. 1998. Borror and DeLong's Introduction to the Study of Insects. 7th Ed. Thomson/ Brooks/ Cole, USA/Australia.

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Objective

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

Theory**UNIT I**

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

UNIT II

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

UNIT III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion. 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 Prizibram'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.

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Learning outcomes

- 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.

Suggested Reading

- Begon, M., Townsend, C.R. and Harper, J. L. 2006. Ecology: From Individuals to Ecosystems. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.
- Chapman J. L. and Reiss MJ. 2006. Ecology: Principles and Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.
- Fowler, J., Cohen, L. and Jarvis, P. 1998. Practical Statistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.
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Objectives

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

Theory**Unit I**

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

Unit II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc., their mode of action. Biological control of weeds using insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

Unit III

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

Unit IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers; Visits to bio-control laboratories to learn rearing and mass production of egg, 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 of the role of natural enemies in managing pest populations below those causing economic damage. Learn the techniques for mass production of quality bio-agents and their optimal use in IPM

Suggested Reading

- Burges HD and Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London.
- De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman and Hall, New York.
- Dhaliwal GS and Arora R. 2001. Integrated Pest Management: Concepts and Approaches. Kalyani Publishers, New Delhi.
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- Ignacimuthu SS and Jayaraj S. 2003. Biological Control of Insect Pests. Phoenix Publ., New Delhi.
- Saxena AB. 2003. Biological Control of Insect Pests. Anmol Publ., New Delhi.
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Objective

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory**UNIT I**

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

UNIT II

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature; categorization of insecticides on the basis of toxicity - criteria for bees, beneficial insects and other insects in general; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrazoles, 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 outcomes

- 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.

Suggested Readings

- Chattopadhyay SB. 1985. Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.
- Gupta HCL. 1999. Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur.
- Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
- Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.



- Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.
- Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publication, New York.
- Pedigo, L.P. and Marlin, E. R. 2009. Entomology and Pest Management, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
- Dovener, R.A. Mueninghoff, J.C. and Volgar, G.C. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA
- Dodia, D.A. Petel, I.S. and Petal, G.M. 2008. Botanical Pesticides for Pest Management. Scientific Publisher (India), Jodhpur.
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- Mathews G.A. 2002. Pesticide Application Methods. 4th Ed. Intercept. UK.
- Otto, D. and Weber, B. 1991. Insecticides: Mechanism of Action and Resistance. Intercept Ltd., U.K.
- Roy, N.K. 2006. Chemistry of Pesticides. Asia Printograph Shahdara Delhi.
- Krieger, R. I. 2001. Handbook of Pesticide Toxicology. Vol-II. Academic Press. Orlando Florida.

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Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

Role of biotechnology in plant resistance to insects.

Practical

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

Learning outcomes

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.

Suggested Readings

- Dhaliwal GS and Singh R. (Eds). 2004. Host Plant Resistance to Insects -Concepts and Applications. Panima Publ., New Delhi.
- Maxwell FG and Jennings PR. (Eds). 1980. Breeding Plants Resistant to Insects. John Wiley and Sons, New York.
- Painter RH. 1951. Insect Resistance in Crop Plants. MacMillan, London.
- Panda N and Khush GS. 1995. Plant Resistance to Insects. CABI, London.
- Smith CM. 2005. Plant Resistance to Arthropods - Molecular and Conventional Approaches. Springer, Berlin.

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Objective

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.

Theory**UNIT I**

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

UNIT II

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

UNIT III

Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; 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 outcomes

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 take management decisions.

Suggested Readings

- Dhaliwal GS and Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publ., New Delhi.
- Horowitz AR and Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi. Ignacimuthu SS and Jayaraj S. 2007. Biotechnology and Insect Pest Management. Elite Publ., New Delhi.
- Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi.
- Norris RF, Caswell-Chen EP and Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.

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

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Objective

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

Theory

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

Insect pest scenario in relation to climate change.

UNIT I

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

UNIT II

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

UNIT III

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

Practical

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

Learning outcomes

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

Suggested Readings

- David, BV and Ramamurthy, VV. 2001. Elements of Economic Entomology. Popular Book Depot, Chennai.
- Dhalliwal GS, Singh R and Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
- Dunston AP. 2007. The Insects: Beneficial and Harmful Aspects. Kalyani Publ., New Delhi.
- Evans JW. 2005. Insect Pests and their Control. Asiatic Publ., New Delhi.
- Nair MRGK. 1986. Insect and Mites of Crops in India. ICAR, New Delhi.
- Prakash I and Mathur RP. 1987. Management of Rodent Pests. ICAR, New Delhi.
- Saxena RC and Srivastava RC. 2007. Entomology at a Glance. Agrotech Publ. Academy, Udaipur.

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Objectives

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

Theory

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

Unit I

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

Unit II

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

Unit III

Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine, etc.

Unit IV

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

Practical

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

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.

Suggested Reading

- Atwal AS and Dhaliwal GS. 2002. Agricultural Pests of South Asia and their Management. Kalyani Publishers, New Delhi.
- Batani DK and Jotwani MG. 1984. Insects and Vegetables. Periodical Expert Book Agency, New Delhi.
- Dhaliwal GS, Singh R and Chhillar BS. 2006. Essential of Agricultural Entomology. Kalyani Publishers, New Delhi.
- Srivastava RP. 1997. Mango Insect Pest Management. International Book Distr., Dehra Dun.
- Verma J.R, Verma AK and Goutham DC. 2004. Pest Management in Horticulture Crops: Principles and Practices. Asiatech Publ., New Delhi.

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Objective

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory**UNIT I**

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses in toto vis-à-vis total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.

UNIT II

Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

UNIT III

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

UNIT IV

Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/sanitation, disinfestations of stores/receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical 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, IIS) 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, IGSMRI, Hapur etc. (only where logistically feasible).

Learning outcomes

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

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management. Detection of insect infestation and familiarization with different storage structures. Learning preventive and curative measures to manage infestation in storage houses.

Suggesting Readings

- Hall DW. 1970. Handling and Storage of Food Grains in Tropical and Subtropical Areas. FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.
- Jayas DV, White NDG and Muir WE. 1995. Stored Grain Ecosystem. Marcel Dekker, New York.
- Khader V. 2004. Textbook on Food Storage and Preservation. Kalyani Publ., New Delhi.
- Khare BP. 1994. Stored Grain Pests and Their Management. Kalyani Publ., New Delhi.
- Subramanyam B and Hagstrum DW. 1995. Interrelated Management of Insects in Stored Products. Marcel Dekker, New York.

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Objectives

To teach the students about the different groups of insects that act as vectors of plant pathogens, vector-plant pathogen interaction, and management of vectors for controlling diseases.

Theory**Unit I**

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

Unit II

Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

Unit III

Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

Unit IV

Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

Unit V

Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; Culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies; Vector rearing and maintenance; Estimating vector transmission efficiency, studying vector-virus host interaction.

Learning outcome

Students are expected to be well versed with insect vectors of plant pathogens, acquire knowledge on disease transmission and vector management techniques.

Suggested Reading

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

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Objective

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

Theory**UNIT I**

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.

UNIT II

Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers.

UNIT III

Uses of light, transmission and scanning electron microscopy.

UNIT IV

Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE.

UNIT V

Use of tissue culture techniques in plant protection. Computer application for predicting/forecasting pest attack and identification.

Learning outcomes

Students are expected to have a good knowledge of different plant protection equipments and techniques related to pest forecasting.

Suggested Readings

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

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Objectives

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

Theory**Unit I**

Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races; Morphology and anatomy of honey bee; Honey bee biology, ecology, adaptations; Honey bee behaviour - nest founding, comb construction, brood care, defense, other in-house and foraging activities; Bee pheromones; Honey bee communication.

Unit II

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

Unit III

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 IV

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 V

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

Practical

Morphological characteristics of honey bee; Mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees; Recording of colony performance; Seasonal bee husbandry practices; Swarming, queenlessness, swarming, laying workers menaces, etc. and their remedies; Innovative techniques in mass queen bee rearing; selection and breeding of honey bees; Instrumental insemination; formulation of artificial diets and their feeding; Production technologies for various hive products; Bee enemies and diseases and their management; Recording pollination efficiency; Application of various models for determining pollination requirement of crop; Developing a beekeeping project.

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 develop entrepreneurial skills for apiculture.

Suggested Reading

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- Abrol DP and Sharma D. 2009. Honey Bee Mites and Their Management. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2009. Honey bee Diseases and Their Management. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2010. Beekeeping: A Compressive Guide to Bees and Beekeeping. Scientific Publishers, India.
- Abrol DP. 2010. Bees and Beekeeping in India. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2012. Pollination Biology: Biodiversity Conservation and Agricultural Production. Springer.
- Atwal AS. 2001. World of Honey Bees. Kalyani Publishers, New Delhi- Ludhiana, India.
- Atwal AS. 2000. Essentials of Beekeeping and Pollination. Kalyani Publishers, New Delhi-Ludhiana, India.
- Bailey I. and Ball BV. 1991. Honey Bee Pathology. Academic Press, London.
- Crane Eva and Walker Penelope. 1983. The Impact of Pest Management on Bees and Pollination. Tropical Development and Research and Institute, London.
- Free JB. 1987. Pheromones of Social Bees. Chapman and Hall, London.
- Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. Mass Multiplication of Honey Bee Colonies. ICAR, New Delhi, India.
- Graham Joe M. 1992. Hive and the Honey Bee. Dadant & Sons, Hamilton, Illinois, USA.
- Groot RA. 1975. Hive and the Honey Bee. Dadant & Sons, Hamilton, Illinois, USA.
- Holm E. 1995. Queen Rearing Genetics and Breeding of Honey Bees. Gedved, Denmark.
- Laidlaw III Jr and Eckert JE. 1962. Queen Rearing. Berkeley, University of California Press.
- Laidlaw III. 1979. Contemporary Queen Rearing. Dadant & Sons, Hamilton, Illinois, USA.
- Mishra RC. 2002. Perspectives in Indian Apiculture. Agro-Botanica, Jodhpur, India.
- Mishra RC. 1995. Honey Bees and their Management in India. I.C.A.R., New Delhi, India.
- Morse AA. 1978. Honey Bee Pests, Predators and Diseases. Cornell University Press, Ithaca and London.
- Rahman, A. 2017. Apiculture in India, ICAR, New Delhi
- Ribbands CR. 1953. The Behaviour and Social Life of Honey Bees. Bee Research Association Ltd., London, UK.
- Rinderer TE. 1986. Bee Genetics and Breeding. Academic Press, Orlando.
- Sardar Singh. 1962. Beekeeping in India. I.C.A.R., New Delhi, India (Reprint: 1982).
- Seeley TD. 1985. Honey Bee Ecology. Princeton University Press, 216 pp.
- Snodgrass RE. 1925. Anatomy and Physiology of the Honey Bee. Mc Graw Hill Book Co., New York & London.
- Snodgrass RE. 1956. Anatomy of the Honey Bee. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

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Objectives

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

Theory**Unit I**

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

Unit II

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

Unit III

Silkworm origin - classification based on voltinism, moultnism, 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, stilling, 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 all the practices of rearing for silk production. They should

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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.

Suggested Reading

- Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.
- Govindalab G, VP, Sharma DD, Rajadurai S and Nishita V Naik. 2005. A text book on mulberry crop protection. Central Silk Board, Bangalore. 450 p.
- Jolly MS, Sen SK, Sonwalkar TN and Prasad GK. 1980. Non-mulberry Silks. FAO Agricultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.
- Mahadevappa D, Halliyal VG, Shankar DG and Ravindra Bhandiwad. 2000. Mulberry Silk Reeling Technology. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi. 234 p.
- Mohanty PK. 2003. Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, 197 p.
- Nataraju B, Sathyaprasad K, Manjunath D and Kumar A. 2005. Silkworm crop protection. CSB, Bangalore. 412 pp.
- Rangaswami G, Narasimhanna MN, Kasiviswanathan K, Sastry CR and Jolly MS. 1976. Food Plants of non-mulberry silkworms. In: Mulberry cultivation. FAO Agricultural Services Bulletin. Vol.1, Chapter-13. Rome, Italy. 96 p.
- Tribhuvan Singh and Saratchandra B. 2004. Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 pp.



Objectives

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

Theory**Unit I**

History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

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

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 perfect the most suitable techniques for lac production with a good knowledge about diseases and natural enemies of the lac insect. With practical training it is expected that students are able to guide landless labourers, who bring stick lac as forest produce.

Suggested Reading

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

Sharma KK and Ramani S. 2010. Recent advances in lac culture. ICAR-IINRG, Ranchi.

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Plant Pathology (Minor Courses)

PL.PATH 505

Principles of Plant Pathology 3(2+1)

Objectives

To introduce the subject of Plant Pathology, its concepts and principles.

Theory

Unit I

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit II

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Unit III

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

Unit IV

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

Practical

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

Suggested Reading

- Agrios GN. 2005. Plant Pathology. 5th Ed. Academic Press, New York.
- Heltefuss R and Williams PH. 1976. Physiological Plant Pathology. Springer Verlag, Berlin, New York.
- Mehrotra RS and Aggarwal A. 2003. Plant Pathology. 2nd Ed. Oxford & IBH, New Delhi.
- Singh RP. 2012. Plant Pathology 2nd edn. Kalyani Publishers, New Delhi.
- Singh RS. 2017. Introduction to Principles of Plant Pathology. 5th edn. MedTech, New Delhi.
- Singh DP and Singh A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi.
- Upadhyay RK. and Mukherjee KG. 1997. Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH, New Delhi.

Objective:

To impart knowledge about symptoms, epidemiology of different diseases of vegetables and spices and their management.

Theory**UNIT I**

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

UNIT II

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

UNIT III

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, nutmeg, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger. Biotechnological approaches in developing disease resistant transgenics.

Practical

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

Suggested Readings

- Chauhe BS, Singh BS, Mukhopadhyay AN & Kumar J. 1992. Plant Diseases of International Importance, Vol. II. Diseases of Vegetable and Oilseed Crops. Prentice Hall, Englewood Cliffs, New Jersey.
- Gupta VK & Paul YS. 2001. Diseases of Vegetable Crops. Kalyani Publ., New Delhi
- Sherl AF & McNab AA. 1986. Vegetable Diseases and their Control. Wiley InterScience, Columbia. Singh RS. 1999. Diseases of Vegetable Crops. Oxford & IBH, New Delhi.
- Gupta SK & Thind TS. 2006. Disease Problem in Vegetable Production. Scientific Publ., Jodhpur. Walker JC. 1952. Diseases of Vegetable Crops. McGraw-Hill, New York

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Theory

Unit I

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

Unit II

Diseases of Pulse crops- Gram, urd bean, mungbean, lentil, pigeonpea, soybean and cowpea.

Unit III

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

Unit IV

Diseases of Cash crops- Cotton, sugarcane.

Unit V

Diseases of Fodder legume crops- Berseem, oats, guar, lucerne.

Unit VI

Medicinal crops- Plantago, liquorice, Mulathi, Rosagrass, sacred basil, Mentha, Ashwagandha, Aloe Vera.

Practical

Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops; Collection and dry preservation of diseased specimens of important crops.

Suggested Reading

- *Joshi IM, Singh DV and Srivastava KD. 1984. Problems and Progress of Wheat Pathology in South Asia. Malhotra Publ. House, New Delhi.*
- *Rangaswami G. 1999. Diseases of Crop Plants in India. 4th Ed. Prentice Hall of India, New Delhi.*
- *Baconel C, Egan BT, Gillaspie Jr AG and Hughes CG. 1989. Diseases of Sugarcane, Major Diseases. Academic Press, New York.*
- *Singh RS. 2017. Plant Diseases. 10th Ed. Medtech, New Delhi.*
- *Singh US, Mukhopadhyay AN, Kumar J and Chaube HS. 1992. Plant Diseases of International*
- *Importance. Vol. 1. Diseases of Cereals and Pulses. Prentice Hall, Englewood Cliffs, New Jersey.*

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Statistics (Supporting Courses)

STAT 502

Statistical Methods for Applied Sciences

4(3+1)

Objectives

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

Theory

Unit I

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

Unit II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.

Unit III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

Unit IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

Unit V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

Practical

Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal. Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model. Non-parametric tests. ANOVA: One way, Two Way, SRS.

Suggested Reading

Prof. Mary Se. Padua

- Goon A.M, Gupta M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.
- Hoel P.G. 1971. Introduction to Mathematical Statistics. John Wiley.
- Hogg R.V and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.
- Hogg RV, McKean JW, Craig AT. 2012. Introduction to Mathematical Statistics 7th Edition.
- Siegel S, Johan N & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
- Anderson TW. 2009. An Introduction to Multivariate Statistical Analysis, 3rd Ed. John Wiley
- <http://freestatistics.altervista.org/en/learning.php>.
- <http://www.statsoft.com/textbook/stathome.html>.

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Objectives

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory**Unit I**

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments, Analysis with missing data, Split plot and strip plot designs.

Suggested Reading

- Cochran WG and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
- Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.
- Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.
- Federer WT. 1985. Experimental Designs. MacMillan.
- Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
- Nigam AK and Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.

Prof. Manoj Kumar Singh

- Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.
- www.drs.icar.gov.in.

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Compulsory (Non-credit Courses)

PGS 501

LIBRARY AND INFORMATION SERVICES

1(0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

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PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 1(0+1)

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing – Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
- Collins' Cobuild English Dictionary. 1995.
- Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.
- Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
- James HS. 1994. Handbook for Technical Writing. NTC Business Books.
- Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East- West Press.
- Mohan K. 2005. Speaking English Effectively. MacMillan India.
- Richard WS. 1969. Technical Writing.
- Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
- Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
- Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

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PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE

1(1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, ownership and period of protection; National biological materials, ownership and period of protection; Convention on Biodiversity protection. initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

- Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
- Ministry of Agriculture, Government of India, 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
- Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
- The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

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PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 1(0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings

- Farr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
- Gabb MH & Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

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Objective

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

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility. UNIT II Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics. UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group - Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

- Bhailla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
- Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
- Singh K., 1998. Rural Development - Principles, Policies and Management. Sage Publ.

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