



Deen Dayal Upadhyaya Gorakhpur University,
Gorakhpur 273009

COURSE CURRICULUM AND SYLLABUS
OF
M. Sc. (Ag.) Entomology

Nomenclature and Credit hour

(On the recommendations of the members of National Core Group, 19 Broad Subject Matter Area (BSMA), ICAR)

Nomenclature	Credit hours
Major Courses	20
Minor Courses	08
Supporting Course	06
Common Courses	05
Credit Seminar	01
Research work or Research Methodology	30
Total	70

Major courses: From the discipline in which a student takes admission.

Minor courses: From the subjects closely related to a student's major subject. It is suggested that the student may choose minor courses as these are related to policy advocacy and aim to build larger understanding of the subject. The final choice of the minor courses should be mandatorily approved by the Student Advisory committee/HOD.

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its Management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the Head of Department (HoD)/ Board of Studies (BoS).

Name of Programme: M.Sc. (Ag.) Entomology

Academic eligibility for admission: - B.Sc. (Ag.)

Curriculum and Syllabus

Course code	Course Title	Credit
Major Courses		20
ENT 501	Insect Morphology	2(1+1)
ENT 502	Insect Anatomy and Physiology	3(2+1)
ENT 503	Insect Taxonomy	3(2+1)
ENT 504	Insect Ecology	2(1+1)
ENT 506	Toxicology of Insecticides	3(2+1)
ENT 508	Concepts of Integrated Pest Management	2(2+0)
ENT 509	Pests of Field Crops	3(2+1)
ENT 510	Pests of Horticultural and Plantation Crops	2(1+1)
Minor Courses		08
ENT 505	Biological Control of Crop Pests and Weeds	3(2+1)
ENT 507	Host Plant Resistance	2(1+1)
*GPB 509	Hybrid Breeding	3(2+1)
Supporting Courses		06
STAT 502	Statistical Methods for Applied Sciences	3(2+1)
STAT 511	Experimental Designs	3(2+1)
Common Courses		05
PGS-501	Library and Information Services	1(0+1)
PGS-502	Technical Writing and Communications Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)
Seminar		01
ENT 591	Master's Seminar	1(0+1)
Thesis Research/Special paper		30
#ENT 599	Master's Research (Thesis) or Special paper (Entomological Research Methodology)	30
Total Credit		70

*Minor course covered by Department of Genetics and Plant Breeding

#Satisfactory/Non-satisfactory

Semester Wise Course Distribution

Course code	Course Title	Credit
Semester I		
ENT 501	Insect Morphology	2(1+1)
ENT 502	Insect Anatomy and Physiology	3(2+1)
ENT 503	Insect Taxonomy	3(2+1)
ENT 504	Insect Ecology	2(1+1)
*GPB 509	Hybrid Breeding	3(2+1)
STAT 502	Statistical Methods for Applied Sciences	3(2+1)
PGS-501	Library and Information Services	1(0+1)
PGS-502	Technical Writing and Communications Skills	1(0+1)
		18
Semester II		
ENT 505	Biological Control of Crop Pests and Weeds	3(2+1)
ENT 506	Toxicology of Insecticides	3(2+1)
ENT 507	Host Plant Resistance	2(1+1)
ENT 509	Pests of Field Crops	3(2+1)
STAT 511	Experimental Designs	3(2+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)
		16
Semester III		
ENT 508	Concepts of Integrated Pest Management	2(2+0)
ENT 510	Pests of Horticultural and Plantation Crops	2(1+1)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(0+1)
		5
Semester IV		
ENT 591	Master's Seminar	1(0+1)
#ENT 599	Master's Research (Thesis) or Special paper (Entomological Research Methodology)	30
		31

*Minor course covered by Department of Genetics and Plant Breeding

#Satisfactory/Non-satisfactory

ENTOMOLOGY

Syllabus

ENT 501 INSECT MORPHOLOGY

2(1+1)

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

Theory

UNIT I: Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

UNIT II: Head- Origin, structure and modification; types of mouthparts and antennae, tentorium and neck sclerites.

UNIT III: Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications.

UNIT IV: Abdomen- Segmentation and appendages; Genitalia and their modifications; Embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs (mechano-, photo- and chemoreceptors).

Practical

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

Suggested Reading

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

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

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

Snodgrass RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.

ENT 502 INSECT ANATOMY AND PHYSIOLOGY

3(2+1)

Objective: To impart knowledge to the students on basic aspects of anatomy of different systems, elementary physiology, nutritional physiology and their application in entomology.

Theory

UNIT I: Scope and importance of insect anatomy and physiology.

UNIT II: Structure, modification and physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, reproductive, endocrine and exocrine glands.

UNIT III: Thermodynamics; moulting; growth, metamorphosis and diapause.

UNIT IV: Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular 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.

Suggested Reading

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

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.

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

ENT 503 INSECT TAXONOMY

3(2+1)

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

Theory

UNIT I: History of Insect classification, Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho- species, infra-specific categories. Identification methods, Polythetic and Polymorphic taxa, Sexual dimorphism, Nomenclature: Common vs scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of

ICZN. Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes

UNIT II: Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- Orders contained.

UNIT III: 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 IV: Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

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

Suggested Reading

Gullan PJ and Cranston PS. 2010. *The Insects: An outline of Entomology*. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.

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

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

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

ENT 504 INSECT ECOLOGY

2(1+1)

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

Theory

UNIT I: History and Definition. Basic Concepts. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects. 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.

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. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion. Prey-predator interactions- Basic model- Lotka-Volterra Model, Volterra's principle. Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration.

UNIT IV: Community ecology- Concept of guild, Organisation of communities. Pest management as applied ecology.

Practical:

- Types of distributions of organisms.
- Methods of sampling insects,
- Estimation of densities of insects.
- Measurement of Micro-environment,
- Constructions of Life table.

- 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 some diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values.
- Field visits to understand different ecosystems and to study insect occurrence in these systems.

Suggested Reading

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

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

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

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

ENT 505 BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS

3(2+1)

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

Theory

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

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

UNIT III: Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation.

UNIT IV: Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semi chemicals 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.

Suggested Reading

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.

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.

ENT 506 TOXICOLOGY OF INSECTICIDES

3(2+1)

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

Theory

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

UNIT II: Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature. Structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds, etc.

UNIT III: Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides-synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity.

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

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

Practical

- Insecticide formulations and mixtures;
- Laboratory and field evaluation of bio-efficacy of insecticides;

- Bioassay techniques;
- Probit analysis;
- Evaluation of insecticide toxicity;
- Toxicity to beneficial insects;
- Pesticide appliances;
- Working out doses and concentrations of pesticides;
- Procedures of residue analysis.

Suggested Reading

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

Matsumura F. 1985. *Toxicology of Insecticides*. Plenum Press, New York.

Pedigo LP and Marlin ER. 2009. *Entomology and Pest Management*, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.

Roy NK. 2006. *Chemistry of Pesticides*. Asia Printograph Shahdara Delhi.

ENT 507 HOST PLANT RESISTANCE

2(1+1)

Objective: To familiarize the students with types, basis, mechanisms and genetics of resistance in plants to insects and role of plant resistance in pest management.

Theory

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

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

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

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

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

UNIT VI: Role of biotechnology in plant resistance to insects.

Practical

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

- Demonstration of antibiosis, tolerance and antixenosis.

Suggested Reading

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

ENT 508 CONCEPTS OF INTEGRATED PEST MANAGEMENT

2(2+0)

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

Theory

UNIT I: History and origin, definition and evolution of various related terminologies.

UNIT II: Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

UNIT III: Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; 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.

Practical:

- Characterization of agro-ecosystems;
- Sampling methods and factors affecting sampling;
- Population estimation methods;
- Crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses.
- Computation of EIL and ETL;
- Crop modeling; designing and implementing IPM system.

Suggested Reading

- Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publishers, 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.

ENT 509 PESTS OF FIELD CROPS

3(2+1)

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

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

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

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

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

UNIT IV Important pests viz., insect, mites, rodents, birds and microorganisms (their systematic position, identification, distribution, host range, biology, nature and extent of damage role of field and cross infestation) associated with stored grain.

UNIT V Storage structure i.e., traditional improved and modern storage structures. Preventive measures – hygiene/sanitation, disinfestation of stores/ receptacles, legal methods. Curative measures, non-chemical control measures- ecological, mechanical, physical, cultural and biological.

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.
- Collection, identification and familiarization with the stored grains/seed insect pests and nature of damage caused by them;
- Estimation of losses in stored food grains

Suggested Reading

David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.

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

Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publishers, New Delhi

Saxena RC and Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.

ENT 510 PESTS OF HORTICULTURAL AND PLANTATION CROPS**2(1+1)**

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

Theory: Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance 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, coconut. Spices and Condiments- pepper, cardamom, clove, chillies, turmeric, ginger, betel vine etc.

UNIT IV: Ornamental, medicinal and aromatic plants and pests in polyhouses/protected cultivation

Practical

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

Suggested Reading

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

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

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

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

ENT 591 Seminar**1(0+1)**

The seminar paper will be related to the area of research of the candidate and the candidate should have to give a seminar presentation of it.

ENT-599 (Special Paper) Entomological Research Methodology

UNIT I: Research Methodology at a glance

Importance and scope of research in agricultural entomology in relation to development of agriculture, Fundamental and applied problems in entomology and their implications, steps involved in any research project, recording, transformation, tabulation, diagrammatic presentation of data in various types of research problems, literature collection, preparation of synopsis and scientific papers.

UNIT II: Toxicological & Physiological Research Methodology

Scope of toxicology in agriculture, Research designs in field, storage and laboratory for estimation of toxicity of insecticides and other chemical agents used against insects, exercises on probit analysis, residue deposit per unit area, persistence, tolerance limits, half life values, PT index, LC 50, Ld 50, LT 50 values, methods of determination of insecticidal residues, Determination of resistance to insecticides.

Bio-chemistry and role of proteins, carbohydrates lipids, vitamins and amino acids in nutritional requirement using modern methods of analysis, preparation of synthetic diets of insects. Physiology of host selection in insects, Elementary knowledge of paper chromatography, TLC, GIC, and other modern analytical methods. Micro-techniques, Histology of different parts and organs. Determination of pH of different parts of alimentary canal.

UNIT III: Entomological Techniques

Techniques involved in collection, killing, preservation, pinning, setting, labeling, handling, rearing and storing of insects, Insectory and insect cages, Determination of temperature and humidity and other entomological techniques, preparation of specimen for transferring them for identification.

UNIT IV: IPM Package of Field Crops

Assessment of losses in fields and storages, computation and analysis of data. Economics of insect control. Collection and identification of important crop pests and their natural enemies, field observations on damage caused by insect-pests, study of life history of insect-pests from cereal, fibre, oilseed, pulses and sugarcane crops.

UNIT V: IPM Package of Horticultural Crops

Collection and identification of important fruit and vegetable crop pests and their natural enemies, field observations on damage caused by insect-pests, study of life history of insect-pests of vegetables like tomato, chilli, cabbage, cauliflower, brinjal, okra, all gourds and fruits like mango, guava, banana, papaya, citrus and other important fruits of this region.

Aim of the course

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

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>.

STAT 511 Experimental Designs

3(2+1)

Aim of the course

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.

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

www.drs.icar.gov.in.

PGS 501 LIBRARY AND INFORMATION SERVICES

(0+1)

Objective

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

Practical

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

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS

(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

Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995.

Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.

Holt, Rinehart and 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.

Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.

Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE

(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, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH and 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 and Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M and 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; The Biological Diversity Act, 2002

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES

(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 vaccumets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

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

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

PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES

(1+0)

Objective

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

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS and 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.

Course Title: Hybrid Breeding

Course Code: GPB 509

Credit Hours: 3(2+1)

Theory

Unit I

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; PreMendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Unit II

Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F₂ and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, their improvement for increasing heterosis.

Unit III

Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self-pollinated, cross pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

Unit IV

Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid; Organellar heterosis and complementation.

Unit V

Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed- mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

Practical

Characterization of male sterile lines using morphological descriptors; Restorer line identification and diversification of male sterile sources; Male sterile line creation in crop plants, problems in creation of

CGMS system, ways of overcoming them; Diversification and restoration; Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeon pea; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops; Estimation from the various models for heterosis parameters; Hybrid seed production in field crops—an account on the released hybrids, their potential, problems and ways of overcoming it; Hybrid breeding at National and International level, opportunities ahead.

Suggested Reading

- Agarwal RL. 1998. Fundamental of Plant Breeding and hybrid Seed Production. Science Publisher London.
- Akin E. 1979. The Geometry of Population Genetics. Springer-Verlag.
- Ben HL. 1998. Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.
- Chal GS and Gossal SS. 2002. Principles and procedures of Plant Breeding, Biotechnology and Convventional Approaches. Narosa Publishing House. New Delhi
- De JG. 1988. Population Genetics and Evolution. Springer-Verlag. 30 January 2012 Hartl
- DL. 2000. A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.
- Mettler LE and Gregg TG. 1969. Population Genetics and Evolution. Prentice-Hall. 25 April 1988
- Montgomery DC. 2001. Design and Analysis of Experiments. 5th Ed., Wiley & Sons. 2013
- Mukherjee BK. 1995. The Heterosis Phenomenon. Kalyani Publishers, New Delhi.
- Proceedings of Genetics and Exploitation of Heterosis in Crops – An International Symposium CIMMYT, 1998.
- Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin. 30 May 1997
- Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
- Srivastava S and Tyagi R. 1997. Selected Problems in Genetics. Vols. I, II. Anmol Publ.
- Virmani SS. 1994. Heterosis and Hybrid Rice Breeding. Monographs of " Theoretical and Applied Genetics", Springer-Verlag.