

Agriculture and Allied Science

Restructured and Revised Syllabi of Post-graduate Programmes

Volume 2 - Plant Protection

- * Agricultural Entomology
- * Nematology
- * Plant Pathology
- * Sericulture

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Compiled By

Dean & Director of Instruction
Co-Ordination Committee
of SAU's 2022-23



**Revision and Implementation of Masters and
Doctoral Program's Syllabi in the SAUs of
Maharashtra as per Recommendation of
ICAR – NCG – BSMA**

**M.Sc. and Ph.D
in
Agricultural Entomology**

**BSMA Syllabi of Post Graduate
Programmes – 2022-23**

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Dr. R.S. Mule
Secretary

Dr. A.L. Narangalkar
Discipline Coordinator
Entomology

Preamble (Plant Protection – Entomology)

The National Core Grant was constituted by ICAR for development of Academic Regulation for Masters and Ph.D. programme. On the recommendations of the National Core Grant, 19 Broad Subject Matter Area (BSMA) Committees were constituted for revising the syllabus. For Plant Protection Dr. S. Lingaraju was the Chairman and Dr. A.K. Bhowmick was the Convener.

The BSMA Committee on Plant Protection meticulously deliberated upon the issues to ameliorate the overall agricultural education programme and Plant Protection in particular. The Curricula and Syllabi of the Master's and Ph.D. Agri. in Entomology were discussed in the meetings convened by the Broad Subject Coordinator, Discipline coordinator and Course leader. The opinion and suggestions invited from experts in all four Agricultural Universities in Maharashtra were reviewed by the committee.

The modified post graduate programme in Plant Protection particularly Entomology has been designed to meet out the demands of Private Sector, advanced research and application, Supplementary Practical Skill required and to enhance national and global competence and employability of our students.

The Master's and Doctoral programmes retain the fundamental aspects e.g. morphology, taxonomy, physiology, biology/bionomics and ecology besides covering the applied aspects of beneficial biota be they (insects, nematodes, fungi and bacteria), their commercial utilization, pests spectrum of specific crop and their management. Various current issues and latest approaches in the subject of Entomology have been given a new thrust. Aiming at improving the theoretical and practical knowledge of the post graduate students. In their respective subject, the number of Master's courses have been increased from 20 (in the previous dispensation) to 23 in Entomology with consideration credit load on the practical aspects. At the doctoral level impetus has been given to research work.

Some of the salient features of the revised curriculum at the Master's level include emphasis on molecular approaches and nanotechnology in entomology; molecular systematic; understanding host plant resistance and breeding for pest resistant crop cultivars; ecological engineering/farmscaping for pest management in conventional and organic farming systems; besides an independent course on integrated management of pest/disease situations (insects, mites, diseases and nematodes) in protected cultivation; independent, advanced training in edible and therapeutic insects, medical and veterinary entomology;

sericulture, apiculture and lac culture to encourage location specific self-employment *vis-à-vis* enhancing farm income; detailed study on post harvest losses due to insects, mites and vertebrate pests and their management; an elaborate exposure to plant quarantine, biosafety and bio-security in view of the rising invasive insect pest infestations and repercussions of climate change. These aspects have been included in the Master's curriculum itself keeping in view of the invasive, exotic pest infestation records as also with a view to cover the details of Indian Biodiversity Act. The course on Commercial Entomology has been split into three separate courses (Apiculture, Sericulture and Lac Culture) to give wider scope for location specific self employment, as envisaged in the National Educational Policy and towards enhancement of farmer's income. At the Doctoral level, the coverage of different courses both theoretical and practical, has been reduced with a view to enable the scholars concentrate on their research work towards achieving significant transferable technologies.

The reader of this note can see that this preamble is meant to give a bird's eye view about our BSMA Committee's recommendations *vis-à-vis* the discipline of Entomology. The Courses at a Glance provided at the beginning of discipline will instantly tell the changes from the previous dispensation of 2009 (the first BSMA effort). There is no gainsaying the fact that the syllabi of each course may be consulted for a larger use.

Committee on Entomology

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' SubCommittees)	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Plant Protection	Entomology	M.Sc. (Ag)	Ph.D.	Dr. C.S. Patil Head Department of Entomology, MPKV, Rahuri	Dr. A.L. Narangalkar, Head (Entomology) Dr. B.S.K.K.V., Dapoli Email: hodentkkv@yahoo.co.in

Implementation of New Curriculum

The universities offering PG programmes in Entomology need to be supported for establishing specialized laboratories equipped with state-of-the art equipments for conducting practical classes especially, Molecular Approaches in Entomology.

One time catch up grant should be awarded to each SAU, offering PG programmes in Entomology for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in discipline of Entomology in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Sc. and Ph.D. Programmes in Entomology will be considered at par with the recommended M.Sc. & Ph.D. programme by Vth Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Entomology throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M.Sc.: 4 Semesters

Ph.D.: 6 Semesters

Name of the Departments / Divisions

- Plant Protection : Entomology

Nomenclature of Degree Programme**(a) M.Sc. Programmes**

- i) M.Sc. (Agri.) in Entomology

(b) Ph. D. Programmes

- i) Ph.D. (Agri.) in Entomology

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 500/600 series courses as well as research topics.
- Lecture schedule and practical schedule has also been given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Credit Requirements

Course Details	Masters Degree	Doctoral Degree
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	70	100

**M.Sc. (Ag.) Entomology
Course Structure**

**LIST OF CORE COURSES/ DEPARTMENT WISE SPECIALIZATION/
COMPULSORY/SUPPORTING COURSES**

1. M.Sc. (Ag.) Entomology

Course Code	Term	Course Title	Credit Hrs.
ENT 501*	I	Insect Morphology	2+1
ENT 502*	I	Insect Anatomy and Physiology	2+1
ENT 503*	II	Insect Taxonomy	1+2
ENT 504*	II	Insect Ecology	2+1
ENT 505*	I	Biological Control of Insect Pests and Weeds	2+1
ENT 506*	II	Toxicology of Insecticides	2+1
ENT 507	II	Host Plant Resistance	1+1
ENT 508*	II	Concepts of Integrated Pest Management	2+0
ENT 509*	I	Pests of Field Crops	2+1
ENT 510*	II	Pests of Horticultural and Plantation Crops	2+1
ENT 511*	I	Post Harvest Entomology	1+1
ENT 512	I	Insect Vectors of Plant Pathogens	1+1
ENT 513	II	Principles of Acarology	1+1
ENT 514	I	Vertebrate Pest Management	1+1
ENT 515	I	Techniques in Plant Protection	0+1
ENT 516	II	Apiculture	2+1
ENT 517	I	Sericulture	2+1

ENT 518	I	Lac Culture	2+1
ENT 519	I	Molecular Approaches in Entomology	2+1
ENT 520	I	Plant Quarantine, Biosafety and Biosecurity	2+0
ENT 521	II	Edible and Therapeutic Insects	1+1
ENT 522	I	Medical and Veterinary Entomology	1+1
ENT 523	II	Forest Entomology	1+1
ENT 591	I	Master's Seminar	0+1
		Total	35+23=58
ENT 599	II	Master's Research	0+30

*** Compulsory Courses**

2. Common Courses: (Non Credit)

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1
PGS 502	I	Technical Writing and Communications Skills	0+1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0
PGS 504	II	Basic Concepts in Laboratory Techniques	0+1
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	III	Disaster Management	1+0

Optional/Supporting Courses :

Course Code	Semester	Course Title	Credit Hrs.
STAT 502		Statistical Methods for Applied Sciences	2+1
STAT 511		Experimental Designs	2+1
STAT 521		Applied Regression Analysis	2+1
BIOCHEM 501		Basic Biochemistry	3+1
BIOCHEM 505		Techniques in Biochemistry	2+2
MCA 512		Information Technology in Agriculture	1+1

1. Statistics
2. Biochemistry
3. Information Technology

(**Note:** The above courses are been offered by various disciplines (The list is only indicative based on the requirement any of the above courses may be opted under the supporting courses). The Syllabi of these courses are available in the respective disciplines. If required the contents may be modified to suit the individual discipline with approval of the concerned BOS).

Minor Disciplines :

1. Agronomy
2. Plant Pathology
3. Agril. Botany
4. Biotechnology
5. Horticulture
6. Organic Farming
7. Plant Physiology
8. Microbiology
9. Agril. Chemistry and Soil Science
10. Plantation, Spices, Medicinal and Aromatic Crops

Deficiency courses:

Course Code	Semester	Course Title	Credit Hrs.
ENTO 411		Fundamentals of Entomology	1+1
ENTO 412		Insect Ecology and Integrated Pest Management	1+1
ENTO 413		Pests of Horticultural Crops and their Management	1+1
ENTO 414		Pests of Crops and Stored Grain and their Management	1+1
ENTO 415		Management of Beneficial Insects	1+1

Semester Layout

M.Sc. Agriculture (in Agril. Entomology)

Semester	Course Code	Course Title	Credit Hrs.	
I	ENT 501*	Insect Morphology	3(2+1)	
	ENT 502*	Insect Anatomy and Physiology	3(2+1)	
	ENT 509 or ENT 511	Pests of Field Crops Post Harvest Entomology	3(2+1) 2(1+1)	
	ENT 505	Biological Control of Insect Pests and Weeds	3(2+1)	
	II	ENT 503* or ENT 504*	Insect Taxonomy Insect Ecology	3(1+2) 3(2+1)
ENT 506*		Toxicology of Insecticides	3(2+1)	
ENT 510* or ENT 516		Pests of Horticultural and Plantation Crops Apiculture	3(2+1) 3(2+1)	
ENT 508*		Concepts of Integrated Pest Management	2(2+0)	
III		ENT 515 or ENT 511* or ENT 514 or ENT 517 or ENT 519 or ENT 520	Techniques in Plant Protection Post Harvest Entomology Vertebrate Pest Management Sericulture Molecular Approaches in Entomology Plant Quarantine, Biosafety and Biosecurity	1(0+1) 2(1+1) 2(1+1) 3(2+1) 3(2+1) 2(2+0)
	ENT 591	Master's Seminar	1(0+1)	
	ENT 599	Master's Research	15(0+15)	
	IV	ENT 599	Master's Research	15(0+15)

* Select any 3 or 4 out of 5 Compulsory Major courses

▪ Select 8 to 12 credits from remaining Major Courses

➤ Supporting courses (6 credits) ENT 519 and ENT 520 from Entomology

Course Code	Sem	Course Title	Credit Hrs.
ENT 507	II	Host Plant Resistance	1+1
ENT 512	I	Insect Vectors of Plant Pathogens	1+1
ENT 513	II	Principles of Acarology	1+1
ENT 518	I	Lac Culture	2+1
ENT 521	II	Edible and Therapeutic Insects	1+1
ENT 522	I	Medical and Veterinary Entomology	1+1
ENT 523	II	Forest Entomology	1+1

Note: Above mentioned Major Courses can be offered on the basis of availability of necessary infrastructure and facilities.

**Ph.D. (Ag.) Entomology
Course Structure**

1. Ph. D. (Ag.) Entomology

Course Code	Term	Course Title	Credit Hrs.
ENT 601**	I	Insect Phylogeny and Systematics	1+2
ENT 602**	II	Insect Physiology and Nutrition	2+1
ENT 603**	I	Insect Ecology and Diversity	2+1
ENT 604	II	Insect Behaviour	1+1
ENT 605**	II	Bio-Inputs for Pest Management	2+1
ENT 606**	I	Insect Toxicology and Residues	2+1
ENT 607	I	Plant Resistance to Insects	1+1
ENT 608	I	Acarology	1+1
ENT 609	I	Molecular Entomology	1+1
ENT 610	II	Integrated Pest Management	2+0
ENT 691	I	Doctoral Seminar-I	0+1
ENT 692	II	Doctoral Seminar-II	0+1
		Total	15+12=27
ENT 699		Doctoral Research	0+75

****Compulsory Courses**

Optional Courses :

Course Code	Semester	Course Title	Credit Hrs.
STAT 502		Statistical Methods for Applied Sciences	2+1
STAT 602		Experimental Designs	2+1
STAT 521		Applied Regression Analysis	2+1
BIOCHEM 501		Basic Biochemistry	3+1
BIOCHEM 505		Techniques in Biochemistry	2+2
MCA 512		Information Technology in Agriculture	1+1

Minor Disciplines :

1. Agronomy
2. Plant Pathology
3. Agril. Botany
4. Biotechnology
5. Horticulture
6. Organic Farming
7. Plant Physiology
8. Microbiology
9. Agril. Chemistry and Soil Science
10. Plantation, Spices, Medicinal and Aromatic Crops

Semester Layout:

Ph.D. Agriculture (in Agril. Entomology)

Semester	Course Code	Course Title	Credit Hrs.
I	ENT 601** or	Insect Phylogeny and Systematics	3(1+2)
	ENT 603**	Insect Ecology and Diversity	3(2+1)
	ENT 606** or	Insect Toxicology and Residues	3(2+1)
	ENT 601	Insect Phylogeny and Systematics	3(2+1)
II	ENT 602** or	Insect Physiology and Nutrition	3(2+1)
	ENT 604 or	Insect Behaviour	2(1+1)
	ENT 605**	Bio-Inputs for Pest Management	3(2+1)
III	ENT 609 or	Molecular Entomology	2(1+1)
	ENT 607	Plant Resistance to Insects	2(1+1)
	ENT 691	Doctoral Seminar-I	1(0+1)
IV	ENT 692	Doctoral Seminar-II	1(0+1)
	ENT 699	Doctoral Research	25(0+25)
V	ENT 699	Doctoral Research	25(0+25)
VI	ENT 699	Doctoral Research	25(0+25)

* Select any 3 courses out of 5 Compulsory Major courses

▪ Select 4 credits from remaining Major courses

➤ Supporting courses (6 credits) ENT 607, ENT 608 and ENT 610 from Entomology

Course Code	Sem	Course Title	Credit Hrs.
ENT 608	I	Acarology	2(1+1)
ENT 610	II	Integrated Pest Management	2(2+0)

Note: Above mentioned Major courses can also be offered

Syllabus for Agril. Entomology

	Course Work	Master's Programme	Doctoral Programme
(I)	Major Courses	20	12
	Minor Courses	08	06
	Supporting Courses	06	05
	Common Courses	05	-
	Seminar	01	02
(II)	Thesis Research	30	75
	Total	70	100

Course Contents

M.Sc. (Ag) in Plant Protection-Entomology

ENT 501	INSECT MORPHOLOGY	3 (2+1)
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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: Definition, Principles, Scope and Importance of Insect Morphology. Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation, general body organization of insects.

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 hemimetabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

Dissection of mouth parts of different insects, 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.

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

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

Gillott, C. 1995. *Entomology*, 2nd Ed. Plenum Press, New York, London.

Gullan, P.J. and Cranston, P.S. 2000. *The Insects, An Outline of Entomology*, 2nd Ed. Blackwell Science, U.K.

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

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

Tembhore, D.B. 2000. *Modern Entomology*, Himalaya Publishing House, Mumbai.

Chu, HF. 1992. *How to Know Immature Insects*. William Brown Publication, Iowa.

Peterson, A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.

Stehr, FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publication, Iowa.

ENT 502

INSECT ANATOMY AND PHYSIOLOGY

3 (2+1)

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. IXIII. Pergamon Press, New York.

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

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

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

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

ENT 503

INSECT TAXONOMY

3 (1 + 2)

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 Panorpooid 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

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

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

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

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

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

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

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

ENT 504

INSECT ECOLOGY

3 (2+1)

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 Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population; ecological engineering.

Practical

Types of distributions of organisms. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting

Holling's Disc equation, Assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild. Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Learning 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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ENT 505 BIOLOGICAL CONTROL OF INSECT 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. 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.

UNIT IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies and packing- 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. Development of insectaries, their maintenance. Visits to bio-control laboratories to learn rearing and mass production (techniques of available bioagent in area wise locations) of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds. Packaging of bioagents. 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 outcomes

- 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 Readings

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 Publ., New Delhi.

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

Huffaker CB and Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

Ignacimuthu SS and Jayaraj S. 2003. *Biological Control of Insect Pests*. Phoenix Publ., New Delhi.

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

Van Driesche and Bellows TS. Jr. 1996. *Biological Control*. Chapman and Hall, New York.

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. Status of Pesticide residue in India. 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.

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

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

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

Prakash, A. David, B.V., J. Rao., Srivastava, S.K., Berliner, J. and Totan Adak. *Synthetic Pesticides*. AZRA Publications.

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

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.

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 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.

ENT 509**PESTS OF FIELD CROPS****3 (2+1)****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, *Spodoptera* sp., *Helicoverpa* sp. 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.

Dhaliwal 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.

ENT 510 PESTS OF HORTICULTURAL AND PLANTATION CROPS 3 (2+1)**Objective**

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

Theory

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

UNIT I

Fruit Crops- mango, guava, banana, jackfruit, papaya, pomegranate, litchi, grapes, ber, fig, citrus, sapota, aonla, jamun, avocado, dragon fruit, custard apple, tamarind, pineapple, apple, peach and other temperate fruits.

UNIT I

Vegetable crops- tomato, potato, sweet potato, radish, carrot, beetroot, cole crops (cabbage, cauliflower, knolkhol), French beans, chow-chow, brinjal, okra, all gourds (pumpkin, bottle gourd, bitter gourd, ridge gourd, sponge gourd, cucumber etc.), drumstick, leafy vegetables (amaranthus, spinach, fenugreek) etc.

UNIT III

Plantation crop- coffee, tea, rubber, coconut, oil palm, arecanut, cashew, cocoa, betelvine etc.; Spices and Condiments- pepper, cinnamon, cardamom, clove, nutmeg, chillies, turmeric, ginger, onion, garlic, curry leaf, cumin, coriander etc.

UNIT IV

Ornamental (croton, rose, gerbera, chrysanthemum, carnation, tuberose, aster, jasmine), medicinal (*aloe vera*, shatavari, ashwagandha, sarpagandha) 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 outcomes

- 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 Readings

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

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

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

ENT 511 POST HARVEST ENTOMOLOGY 2 (1+1)

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, HS) in storage pest management; integrated approaches to stored grain pest management.

Practical

Collection, identification and familiarization with the stored grains/seed insect pests and nature of damage caused by them; detection of hidden insect infestation in stored food grains; estimation of uric acid content in infested produce; estimation of losses in stored food grains; determination of moisture content in stored food grains; familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques; treatment of packing materials and their effect on seed quality. Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, 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 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.

ENT 512 INSECT VECTORS OF PLANT PATHOGENS 2 (1+1)

Objective

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

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

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

Learning outcomes

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

Suggested Readings

Basu AN. 1995. *Bemisia tabaci* (Gennadius) - *Crop Pest and Principal Whitefly Vector of Plant Viruses*. Oxford and IBH, New Delhi.

Harris KF and Maramarosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.

Maramorosch K and Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.

Youdeovei A and Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

ENT 513

PRINCIPLES OF ACAROLOGY

2 (1+1)

Objective

To acquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

Theory**UNIT I**

History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.

UNIT II

Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

UNIT III

Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens etc. Culturing of phytophagous, parasitic and predatory mites. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.

Practical

Collection of mites from plants, soil and animals; extraction of mites from soil, plants and stored products; preparation of mounting media and slide mounts; external morphology of mites; identification of mites up to family level using keys; studying different rearing techniques for mites.

Learning outcomes

- Students are expected to identify mites up to family level.
- Acquire knowledge of mite pests of cultivated crops, their nature of damage, life history traits and effective management.

Suggested Readings

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

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

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

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

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

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

Jeppson LR, Keifer HH and Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.

Krantz GW. 1970. *A Manual of Acarology*. Oregon State Univ. Book Stores, Corvallis, Oregon.

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

Qiang Zhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control*. CABI, London.

Sadana GL. 1997. *False Spider Mites Infesting Crops in India*. Kalyani Publ. House, New Delhi.

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

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

ENT 514 VERTEBRATE PEST MANAGEMENT 2 (1+1)

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods - Operational practices- baiting, equipments and educative programmes.

Practical

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

Learning outcomes

- Students are expected to be well versed with vertebrate pest diversity, their nature of damage, life history traits, behaviour and effective management.

Suggested Readings

Rahman,A. 2020. *Protective and Productive Entomology*. Narendra Publishing House, New Delhi

Fitzwater WD and Prakash I. 1989. *Handbook of Vertebrate Pest Control*. ICAR, New Delhi.

Prakash I and Ghosh PK.1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.

Prakash I and Ghosh RP.1987. *Management of Rodent Pests*. ICAR, New Delhi.

Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay.

Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay.

ENT 515**TECHNIQUES IN PLANT PROTECTION****1 (0+1)****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.

ENT 516

APICULTURE

3 (2+1)

Objective

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

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

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

Practical:

Morphological characteristics of honey bee; mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees; recording of colony performance; seasonal bee husbandry practices; swarming, queenlessness, swarming, laying workers menaces, etc. & 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 outcomes

- 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 Readings

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

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

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

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

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

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

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

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

Crane Eva & 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 & 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.
- Grout RA. 1975. *Hive and the Honey Bee*. Dadant & Sons, Hamilton, Illinois, USA.
- Holm E. 1995. *Queen Rearing Genetics & Breeding of Honey Bees*. Gedved, Denmark.
- Laidlaw HH Jr & Eckert JE 1962. *Queen Rearing*. Berkeley, University of California Press.
- Laidlaw HH. 1979. *Contemporary Queen Rearing*. Dadant & Sons, Hamilton, Illinois, USA.
- Mishra RC 2002. *Perspectives in Indian Apiculture*. Agro-Botanica, Jodhpur, India.
- Mishra RC. 1995. *Honey Bees and their Management in India*. I.C.A.R., New Delhi, India.
- Morse AA. 1978. *Honey Bee Pests, Predators and Diseases*. Cornell University Press, Ithaca and London.
- Rahman, A. 2017. *Apiculture in India*, ICAR, New Delhi
- Ribbands CR. 1953. *The Behaviour and Social Life of Honey Bees*. Bee Research Association Ltd., London, UK.
- Rinderer, TE. 1986. *Bee Genetics and Breeding*. Academic Press, Orlando.
- Sardar Singh 1962. *Beekeeping in India*. I.C.A.R., New Delhi, India (Reprint: 1982).
- Seeley TD. 1985. *Honey Bee Ecology*. Princeton University Press, 216 pp.
- Snodgrass RE. 1925. *Anatomy and Physiology of the Honey Bee*. Mc Graw Hill Book Co., New York & London.
- Snodgrass RE. 1956. *Anatomy of the Honey Bee*. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

ENT 517**SERICULTURE****3 (2+1)****Objective**

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

Theory**Unit I:**

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

Unit II:

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

Unit III:

Silkworm origin – classification based on voltinism, 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, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.

Practical

Morphology of mulberry plants – Identification of popular mulberry genotypes – Nursery bed and main field preparation – planting methods – Identification of nutrient deficiency symptoms – Identification of weeds– pruning and harvesting methods – Identification of pests and diseases of mulberry–*Terminalia arjuna*, *Terminalia tomentosa*, Som and Soalu- Nursery and pruning techniques – Intercultural operations. Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – kaccha shed net houses and shoot feeding method, 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 outcomes :

- 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 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 Readings

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

Govindaiah., G, V.P., Sharma, D.D., Rajadurai, S. and V. NishitaNaik. 2005. *A text book on mulberry crop protection*. Central Silk Board, Bangalore.450 p.

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

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

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

Jolly, M.S., S.K. Sen, T.N. Sonwalkar and G.K. Prasad 1980. *Non-mulberry Silks*. FAO Agricultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.

Rangaswami,G., Narasimhanna, M.N., Kasiviswanathan.K., Sastry, C.R. and M.S. Jolly. 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.

G. Ganga., J. Sulochana Chetty. 2003. *An Introduction to Sericulture*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi. 302 p.

R.K. Datta., H.K. Basavaraja and Yasuhisa Mano. 1996. *Manual on Bivoltine Rearing, Maintenance and Multiplication*, JICA Bivoltine Technology Development Project, CSRTI Mysore. 65 p.

Electronic resources:

www.silkwormgenomics.org; www.silkboard.com; ww.silkgermplasm.com;
www.csrtimys.res.in

ENT 518 LAC CULTURE 3 (2+1)**Objective**

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

Theory**Unit I:**

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

Unit II:

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

Unit III:

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

Unit IV:

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

Unit V:

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

Practical

Lac host cultivation and lac production practices; equipments for lac production; conventional and advanced methods; coupe system of lac production; cultivation of suitable host plants; pruning of host trees; herbarium of host plants; strains of lac insects; brood lac selection and treatment for pest management; slide preparation of adult and immature stages; inoculation of host tree; identification of natural enemies of lac insect and their management; molecular characterization of lac insect where possible; harvesting; process of manufacture of seed lac, shell lac from stick lac; grading of seed lac and shellac; marketing of lac products and by products.

Learning outcomes

- 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 Readings

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

Sharma, K.K. and Ramani, S. 2010. *Recent advances in lac culture*. ICAR – IINRG, Ranchi.

ENT 519 BIOTECHNOLOGICAL APPROACHES IN ENTOMOLOGY 3 (2+1)**Objective**

To acquaint students the latest techniques used in molecular biology.

Theory**UNIT I:**

Introduction to molecular biology, techniques used in molecular biology.

UNIT II:

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

UNIT III:

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

UNIT IV:

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

UNIT V:

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

Practical

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

Learning outcomes

- The students are expected to be well versed with the basic techniques used in molecular biology.

Suggested Readings

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

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

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

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

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

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

Singh B.D. 2008. *Biotechnology (Expanding Horizons)*. Kalyani Publ., New Delhi.

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

ENT 520 PLANT QUARANTINE, BIO-SAFETY AND BIO-SECURITY 2 (2+0)

Objective

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up. Also, to facilitate students to have a good understanding of the aspects of biosafety and biosecurity.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procedures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

UNIT III

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

UNIT IV

WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

Learning outcomes

- Students offering this course are expected to have a good knowledge of the rules and regulations of Plant Quarantine, WTO regulations, GAP, Sanitary and Phytosanitary measures.

Suggested Readings

Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

Rhower GG. 1991. *Regulatory Plant Pest Management*. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental), CRC Press.

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

ENT 521	EDIBLE AND THERAPEUTIC INSECTS	2 (1+1)
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Objectives:

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

Theory**Unit-I:**

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

Unit II:

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

Unit- III:

Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing Unit- IV: Nutritional composition and role of insects in food security Unit V: Insect farming: the concept, definitions, and rearing techniques.

Unit VI:

Processing edible insects for food and feed Unit VII: Food safety and preservation, edible insects for livelihood security

Practical

Survey and identification of edible and therapeutic insect species; collection and preservation of edible and therapeutic insect specimens; rearing techniques of edible insect species; harvesting techniques of edible insects from natural environment; analysis of proximate elemental composition, antioxidant and anti-nutritional properties and microbial aspects of preservation.

Learning outcomes

- Students are expected to be aware of insects for edible and therapeutic use; their nutritional composition.
- Should know the techniques of farming and processing insects for human and animal consumption.

Suggested Readings:

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

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

ENT 522 MEDICAL AND VETERINARY ENTOMOLOGY 2 (1+1)

Objectives:

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

Theory:**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Practical:

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

Learning outcomes

- Students are expected to identify the arthropods of medical and veterinary importance; identify the diseases transmitted by these arthropod vectors and suggest management options.

Suggested Readings:

Gary Mullen Lance Durden 2018. *Medical and Veterinary Entomology*, 3rd Edition, Academic Press.

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

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

ENT 523**FOREST ENTOMOLOGY****2 (1+1)****Objectives:**

to promote a more global theoretical understanding of pest population dynamics and the causes of forest insect outbreaks: covering pests of both natural forests and plantations, the

diversity of tropical forest insects, their ecological functions, the concept of pests and the incidence of pests in natural forests, plantations and stored timber.

Theory:

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

Insect pests in plantations: Location-specific case studies.

Practical

Collection, identification and preservation of important insect pest specimens of forest plants and some damage material; detection of insect infestation and assessment of losses due to

insect pests; habitat management for vertebrate and insects pests; fire control methods and devices. Familiarization with the meteorological and plant protection equipment, application of pesticides and bio-control agents in the management of insect pests in nurseries and plantations.

Learning outcomes

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

Suggested Readings

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

Jha, L. K. and Sen Sarna P. K. 1994. *Forest Entomology*. Ashish Publishing House, Delhi.

Stebbing, E. P. 1977. *Indian Forest Insects*. JK Jain Brothers.

Course Contents

Ph.D. (Ag) in Plant Protection-Entomology

ENT 601	INSECT PHYLOGENY AND SYSTEMATICS	3 (1+2)
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Objective

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

Theory

UNIT I

Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.

UNIT II

Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

UNIT III

Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.

UNIT IV

Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular systematics.

Practical

Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, and construction of taxonomic keys for the selected group. Development of descriptions, photographing, writing diagrams, and preparation of specimens for “type like” preservation. Submission of the collections

made of the group. Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms. Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.

Learning outcomes

- Scholars are expected to understand the concepts of taxonomic hierarchy, study taxonomic characters, variations, intra-specific phenotypic plasticity; prepare taxonomic keys for specific groups and write taxonomic papers and reviews.
- Scholars should be able to identify insects of economic importance up to family/ generic levels and specialize in any one group of insects up to species level identification.

Suggested Readings

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

Dakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. SpringerVerlag, Berlin.

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

Hennig W. 1960. *Phylogenetic Systematics*. Urbana Univ. Illinois Press, USA.

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

Mayr E and Ashlock PD. 1991. *Principles of Systematic Zoology*. 2 nd Ed. McGraw Hill, New York.

Mayr E.1969. *Principles of Systematic Zoology*. McGraw-Hill, New York.

Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie Academic and Professional, London.

Ross HH. 1974. *Biological Systematics*. Addison Wesley Publ. Co., London.

Wiley EO. 1981. *Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists*. Columbia Univ. Press, USA.

ENT 602

INSECT PHYSIOLOGY AND NUTRITION

3 (2+1)

Objective

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

Theory**UNIT I**

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticle.

UNIT II

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

UNIT III

Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

UNIT IV

Endocrine system and insect hormones, physiology of insect growth and development-metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

Practical

Preparation of synthetic diets for different groups of insects; rearing of insects on synthetic, semi-synthetic and natural diets; determination of co-efficient of utilization; qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph; zymogram analyses of amylase; determination of chitin in insect cuticle; examination and count of insect haemocytes.

Learning outcomes

- The scholars are expected to have thorough theoretical and practical knowledge of insect physiology that can be made use of in practical/ applied entomological aspects.
- Understand how physiological systems in insects are integrated to maintain homeostasis.

Suggested Readings

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford and IBH, New Delhi.

Bernays EA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, London.

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

Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Association for Advancement of Entomology, Trivandrum, Kerala.

Rockstein, M. 1978. *Biochemistry of Insects*, Academic Press.

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

ENT 603

INSECT ECOLOGY AND DIVERSITY

3 (2+1)

Objective

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics. Study insect-plant interactions; get acquainted with biodiversity and conservation.

Theory

UNIT I

Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

UNIT II

Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. Host seeking behavior of parasitoids.

UNIT III

Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

UNIT IV

Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

Practical

Methods of data collection under field conditions. Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc. Calculation of sample sizes by different methods. Fitting Poisson and Negative Binomial distributions and working out the data transformation methods. Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies – Calculation of changes under selection, Demonstration of genetic drift. Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/Goniozus/Female Bruchids etc.- A test of reproductive effort and fitness. Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution. Exercises in development of Algorithms for crop modeling.

Learning outcomes

- The scholar is expected to develop expertise in methods of data collection for insect population studies, data transformation for analyses, diversity estimates, assessing distribution parameters, study the impact of abiotic and biotic factors on the distribution and abundance of insects.
- Should gain significant knowledge on construction of life tables and their analyses, assessment of resource size by female insects, reproductive effort and fitness.

Suggested Readings :

Barbosa P and Letourneau DK. (Eds.). 1988. *Novel Aspects of Insect-Plant Interactions*. Wiley, London.

Elizabeth BA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, New York.

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

Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.

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

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

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

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

Southwood TRE and Henderson PA. 2000. *Ecological Methods*. 3rd Ed. Wiley Blackwell, London.

Strong DR, Lawton JH and Southwood R. 1984. *Insects on Plants: Community Patterns and Mechanism*. Harvard University Press, Harvard.

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

ENT 604

INSECT BEHAVIOUR

2 (1+1)

Objective

To acquaint the students with a thorough understanding of how natural selection has led to various survival strategies manifested as behavior in insects.

Theory

UNIT I

Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behavior, inducted behavior, learnt behavior and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behavior- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behavior and behavioural polymorphism.

UNIT II

Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

UNIT III

Reproductive behavior- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behavior- kin selection, parental manipulation and mutualism; Self organization and insect behavior.

UNIT IV

Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behavior, pollination behavior, co-evolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

Practical

Quantitative methods in sampling behavior; training bees to artificial feeders; sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees. Evaluation of different types of traps against fruit flies with respect to signals; Use of honey bees/*Helicoverpa armigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

Learning outcomes

- Scholars are expected to be well versed with the behavior and orientation of insects towards exploitation as a tool in IPM.

Suggested Readings

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford and IBH, New Delhi.

Awasthi VB. 2001. *Principles of Insect Behaviour*. Scientific Publ., Jodhpur.

Bernays EA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, London.

Brown LB. 1999. *The Experimental Analysis of Insect Behaviour*. Springer, Berlin.

Krebs JR and Davies NB. 1993. *An Introduction to Behavioural Ecology*. 3rd Ed. Chapman and Hall, London.

Manning A and Dawkins MS. 1992. *An Introduction to Animal Behaviour*. Cambridge University Press, USA.

Mathews RW and Mathews JR. 1978. *Insect Behaviour*. A Wiley-InterScience Publ. John Wiley and Sons, New York. S

ENT 605**BIO-INPUTS FOR PEST MANAGEMENT****3 (2+1)****Objective**

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

Theory**UNIT I**

Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents vis-à-vis target pest populations.

UNIT II

Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio-agents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

UNIT III

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

UNIT IV

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

Practical

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semio-chemicals on natural enemies, breeding of various bio-control agents, performance of efficiency analyses on target pests; project document preparation for establishing a viable mass-production unit /insectary; observation of feeding behavior acts of predatory bugs/ beetles.

Learning outcomes

- Scholars are expected to learn the mass multiplication techniques of the more common and economically feasible natural enemies to be exploited under IPM programmes.

- They should be able to guide entrepreneurs for establishing a viable mass-production unit /insectary.

Suggested Readings

Burges HD and Hussey NW. (Eds.). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.

Coppel HC and James WM. 1977. *Biological Insect Pest Suppression*. Springer Verlag, Berlin.

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

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

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

Huffakar CB and Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

ENT 606 INSECTICIDE TOXICOLOGY AND RESIDUES 3 (2+1)

Objective

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects. Theory

UNIT I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.

UNIT II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

UNIT III

Joint action of insecticides; activation, synergism and potentiation.

UNIT IV

Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

UNIT V

Pesticide residues and its significance and risk assessment; Estimation of insecticidal residues - sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility; insecticide laws and standards, and good agricultural practices.

Practical

Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods; method validation, calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects; preparation of EC formulation using neem oil; Visit to residue laboratory.

Learning outcomes

- Scholars are expected to be well versed with the latest technologies of bioassays, insecticide/ pesticide residue analysis and solving problems associated with insect resistance to insecticides.

Suggested Readings

Busvine JR. 1971. *A Critical Review on the Techniques for Testing Insecticides*. CABI, London.

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

Hayes WJ and Laws ER. 1991. *Handbook of Pesticide Toxicology*. Academic Press, New York.

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.

O' Brien RD. 1974. *Insecticides Action and Metabolism*. Academic 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 Publ., New York.

ENT 607**PLANT RESISTANCE TO INSECTS****2 (1+1)****Objective**

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

Theory**UNIT I**

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species - gene pool; insect sources – behaviour in relation to host plant factors.

UNIT II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

UNIT III

Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

UNIT IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

Practical

Understanding mechanisms of resistance for orientation, feeding, oviposition etc., allelochemical bases of insect resistance; macroculturing of test insects like aphids, leaf/plant hoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

Learning outcomes

- Scholars are expected to identify sources of resistance in different crops and varieties; their utilization in resistance breeding programmes involving screening techniques for specific pests.

Suggested Readings

Panda N. 1979. *Principles of Host Plant Resistance to Insects*. Allenheld, Osum and Co., New York.

Rosenthal GA and Janzen DH. (Eds.). 1979. *Herbivores – their Interactions with Secondary Plant Metabolites*. Vol. I, II. Academic Press, New York.

Sadasivam S and Thayumanavan B. 2003. *Molecular Host Plant Resistance to Pests*. Marcel Dekker, New York.

Smith CM, Khan ZR and Pathak MD. 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*. CRC Press, Boca Raton, Florida.

ENT 608**ACAROLOGY****2 (1+1)****Objective**

To acquire a good working knowledge of identification of economically important groups of mites up to the species level, a detailed understanding of the newer acaricide molecules and utilization of predators.

Theory**UNIT I**

Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

UNIT II

Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

UNIT III

Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

UNIT IV

Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi-identification, isolation and utilization.

UNIT III

Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Transgenic plants for pest resistance and diseases.

UNIT IV

Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.

UNIT V

DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

Practical

Isolation of DNA/RNA; purity determinations, purification of total DNA from animal tissues; base pair estimation; agarose gel electrophoresis; quantitative enzyme profile of alimentary canal; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

Learning outcomes

- The scholars are expected to have mastered the molecular techniques applicable in entomological research like isolation of insect DNA, purification, DNA barcoding and utilizing these techniques in molecular systematics and biological control aspects.

Suggested Readings

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

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

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

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

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

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

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

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

ENT 610 INTEGRATED PEST MANAGEMENT 2 (2+0)

Objective

To acquaint the students with recent concepts of integrated pest management; surveillance and data base management; successful national and international case histories of integrated pest management, non-conventional tools in pest management.

Theory

UNIT I

Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modeling.

UNIT II

Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.

UNIT III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.

UNIT IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

Learning outcomes

- Having gained sufficient experience in advanced studies of IPM the scholars should be able to independently frame IPM schedules for major crops/ cropping ecosystems (cereal / pulse crop / oilseed crop based/ vegetable crop based agro-ecosystems).

Suggested Readings

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

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

Flint MC and Bosch RV. 1981. *Introduction to Integrated Pest Management*. Springer, Berlin.

- Koul O and Cuperus GW. 2007. *Ecologically Based Integrated Pest Management*. CABI, London.
- Koul O, Dhaliwal GS and Curperus GW. 2004. *Integrated Pest Management –Potential, Constraints and Challenges*. CABI, London.
- Maredia KM, Dakouo D and Mota-Sanchez D. 2003. *Integrated Pest Management in the Global Arena*. CABI, London.
- Metcalf RL and Luckman WH. 1982. *Introduction to Insect Pest Management*. John Wiley and Sons, New York.
- Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.
- Pedigo RL. 1996. *Entomology and Pest Management*. Prentice Hall, New Delhi.
- Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

**Revision and Implementation of Masters and
Doctoral Program's Syllabi in the SAUs of
Maharashtra as per Recommendation of
ICAR – NCG**

**M.Sc. and Ph.D
in
Nematology**

**BSMA Syllabi of Post Graduate
Programmes – 2022-23**

Preamble

Nematodes as a whole live under a variety of conditions and are known to occur everywhere life can exist from arctic to tropics, from heights of mountains to depths of oceans, they may be free living in soil or in water or may live as parasites of animals (including man) or of plants.

The plant nematodes or phytonematodes are those seen associated with plants and constitute one of the most important groups of organisms which live in soil around the roots of plants. Plant parasitic nematodes are a major biotic stress in the successful crop production. Besides inflicting direct losses to crop yields, they play an important role in disease complexes involving other soil-borne plant pathogens. Overall, plant parasitic nematodes cause 21.3% crop losses in field and horticultural crops. Root knot nematodes are economically most important causing yield losses in cereals, pulses, fruits and vegetables. Studies conducted by AICRP on Plant Parasitic Nematodes have revealed that adoption rate of nematode management technologies is meager 28 per cent.

Considering the above scenario, there is a need to update knowledge of the postgraduate students of Nematology. It is, therefore, necessary to formulate and revise the course curricula to include latest developments in the field of nematology. The overall upgradation of course contents are in line with national policy priorities like doubling of farmer's income, more crops per drop, soil health, skill development, entrepreneurship development, etc.

1. Committee of Broad Subject Coordinator and Discipline Coordinators for finalizing the PG- Degree syllabi as per the ICAR-BSMA recommendation

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Sub Committees	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
		M.Sc. (Agri.)	Ph.D.		
Plant Protection	Nematology	M.Sc. (Agri.)	Ph.D.	Dr. C. S. Patil, Head, Department of Agril. Entomology, MPKV, Rahuri Email: : cspatils@rediffmail.com Mobile: 9420291252	Dr. C. S. Patil, Head, Department of Agril. Entomology, MPKV, Rahuri

2. Committee for finalization of new syllabi 2022 for Post Graduation in Nematology

Sr. No.	Name of the member	Designation	Co-opted members from four Agricultural Universities and ICAR Institutes of Maharashtra
1	Dr. S. Lingaraju	Emeritus Professor, UAS, Dharwad	Chairman
2	Dr. C. S. Patil	Head, Department of Agril. Entomology, MPKV, Rahuri	Coordinator
3	Dr. S. R. Kulkarni	Professor (CAS), Department of Agril. Entomology, MPKV, Rahuri	Member
4	Dr. N. L. Mhase	Former Nematologist, AICRP on Nematodes in Agriculture, Department of Agril. Entomology, MPKV, Rahuri	Member
5	Dr. S. S. Pokhare	Nematologist, NRC Pomegranate, Solapur	Co-opted member
6	Dr. Y. E. Thorat	Scientist, ICAR-IISR, Pravaranagar, Loni	Co-opted member
7	Dr. B. D. Shinde	Assistant Professor, Department of Agril. Entomology, Dr. BSKKV, Dapoli	Member
8	Dr. P. R. Palande	Assistant Professor and Officer In-charge of AICRP on Nematodes in Agriculture, Department of Agril. Entomology, MPKV, Rahuri	Secretary

Implementation of New Curriculum

The universities offering PG programmes in Plant Protection need to be supported for establishing specialized laboratories equipped with state-of-the art equipments for conducting practical classes especially, Entomology, Nematology, Plant Pathology and Sericulture.

One time catch up grant should be awarded to each SAU offering PG programmes in Plant Protection for meeting expenditure for upgrading the course requirements. Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under SAU should be given on-job training in reputed national and international Institutes. To execute the new Masters and Ph.D. programmes in different discipline of Plant Protection in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities during initial years.

The already existing M.Sc. and Ph.D. Programmes in Plant Protection like: Agril. Entomology, Plant Pathology, Nematology and Sericulture will be considered at par with the recommended M.Sc. & Ph.D. programme by V Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Plant Protection throughout the country.
- Imparting quality education.
- Development of technical manpower to cater to the need of governments, corporate sector and research organizations in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M. Sc.: 4 Semesters

Ph. D.: 6 Semesters

Name of the Departments / Divisions

- Entomology
- Nematology
- Plant Pathology
- Sericulture

Nomenclature of Degree Programme

(a) M. Sc. Programmes

- i) M.Sc.(Agri.) in Entomology
- ii) M.Sc.(Agri.) in Nematology
- iii) M.Sc.(Agri.) in Plant Pathology
- iv) M.Sc.(Agri.) in Sericulture

(b) Ph. D. Programmes

- i) Ph.D. in Entomology
- ii) Ph.D. in Nematology
- iii) Ph.D. in Plant Pathology
- iv) Ph.D. in Sericulture

Code Numbers

- All courses are divided into two series: 500 series courses pertain to Master's degree programme, and 600 series to Doctoral programmes.
- Credit Seminar for Master's is designated by code no. 591 and the Two Seminars for Doctoral programme are coded as 691 and 692, respectively.
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699.

Course Contents

The contents of each course have been organized into:

- **Objective** – to elucidate the basic purpose.
- **Theory units** – to facilitate uniform coverage of syllabus for question paper setting.
- **Suggested Readings** – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.

- Lecture schedule and practical schedule have also been given at the end of each course to facilitate the teacher to teach the course in an effective manner.

Eligibility for Admission

Master's Degree Programme

B.Sc.(Agri.) / B. Sc. (Hons.) Agriculture/ B. Sc. (Hort.)/ B.Sc. (Hons.) Horticulture/ B. Sc. (Forestry)/ B.Sc. (Hons.) Forestry or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Agriculture conducted by competent authority.

Note:- Students admitted to Agriculture Faculty other than UG degree in Agriculture will have to complete the Deficiency courses with 10-15 credits as prescribed by Student's Advisory Committee (SAC)

▪ **Doctoral Degree Programme**

- (i) Master's Degree in the concerned Department/ Discipline with two years duration and minimum 6.5/10 or equivalent OGPA/equivalent percentage of marks of Agriculture-related Universities and having the Common Entrance Test in Agriculture faculty conducted by MAUEB, Pune or a competent authority as applicable.

Sr. No	Name of Department	Specialization in Ph. D.	Eligibility criteria
1.	Entomology	Ph.D. in Entomology	M. Sc. (Agri.) in Entomology
2.	Nematology	Ph.D. in Entomology	M. Sc. (Agri.) in Nematology
3.	Plant Pathology	Ph.D. in Entomology	M. Sc. (Agri.) in Plant Pathology
4.	Sericulture	Ph.D. in Entomology	M. Sc. (Agri.) in Sericulture

Credit Requirements:

Course Details	Masters Degree	Doctoral Degree
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	70	100

M.Sc. (Agri.) in Nematology

Course Structure

LIST OF CORE COURSES/ DEPARTMENT WISE SPECIALIZATION/ COMPULSORY/ SUPPORTING COURSES

Course Code	Semester	Course Title	Credit Hrs.
NEM 501*		Principles of Nematology	2+1
NEM 502 [§] / ENT 503		Principles of Taxonomy	2+0
NEM 503*		Structural Organization of Nematode	2+1
NEM 504*		Nematode Systematics	2+1
NEM 505*		Nematological Techniques	1+2
NEM 506*		Nematode Diseases of Crops	3+1
NEM 507		Nematode Biology and Physiology	2+1
NEM 508		Nematode Ecology	2+1
NEM 509		Nematode Interactions with Other Organisms	2+1
NEM 510*		Nematode Management	2+1
NEM 511		Beneficial Nematodes	1+1
NEM 512/ ENT 510 [§]		Principles of Integrated Pest Management	1+1
NEM 513/ PL PATH 513 [@]		Disease Resistance in Plants	2+0
NEM 514/ ENT 520 [§]		Plant Quarantine, Biosafety and Biosecurity	2+0
NEM 515/ PATH 521/ ENT 524		IPM in Protected Cultivation	2+1
NEM 591		Master's Seminar	1+0
NEM 599		Master's Research	0+30

***Core courses for Master's**

Minor Disciplines (List of disciplines for minor courses)

1. Entomology
2. Plant Pathology
3. Horticulture

4. Agronomy
5. Soil Science

Supporting courses: (List of courses)

Course Code	Semester	Course Title	Credit Hrs.
STAT 502		Basic Sampling Techniques	2+1
BIOCHEM 501		Basic Biochemistry	3+1
Total			5+2=7

Compulsory Non Credit Deficiency Courses:

Course Code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	1+0
PGS 502	I	Technical Writing and Communications Skills	1+0
PGS 503	II	Intellectual Property and Its Management in Agriculture	1+0
PGS 504	II	Basic Concepts in Laboratory Techniques	1+0
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	III	Disaster Management	1+0

Ph.D. in Nematology

Course Structure

Course Code	Semester	Course Title	Credit Hrs.
NEM 601**		Nematode Phylogeny and Systematics	2+1
NEM 602**		Nematode Disease Development and Host Resistance	2+1
NEM 603**		Advances in Nematode Management	2+1
NEM 604**		Physiological and Molecular Nematology	2+1
NEM 605/ PL PATH 606@		Plant Biosecurity and Biosafety	2+0
NEM 691		Doctoral Seminar I	1+0
NEM 692		Doctoral Seminar II	1+0
NEM 699		Doctoral Research	75
Total			16+9 =25

** Core Courses for Doctoral Programme; @ Cross-listed with Plant Pathology; § Cross-listed with Entomology

Minor Disciplines: (List of disciplines for minor courses)

1. Entomology
2. Plant Pathology
3. Horticulture
4. Agronomy
5. Soil Science

Supporting courses (List of courses)

Course Code	Semester	Course Title	Credit Hrs.
STAT 522		Data Analysis Using Statistical Packages	2+1
BIOCHEM 505		Techniques in Biochemistry	2+2
Total			4+3=7

Course Contents

M.Sc. (Agri.) in Nematology

Course No.	Course Title	Credit Hrs.
NEM 501	Principles of Nematology	2+1

Objective:

To project the importance of Nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

Theory

Unit I

Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; Nematode habitats and diversity- plant, animal and human parasites; useful Nematodes; economic importance of Nematodes to agriculture, horticulture and forestry

Unit II

Gross morphology of plant parasitic nematodes; broad classification, Nematode biology, physiology and ecology.

Unit III

Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

Unit V

Principles and practices of nematode management; integrated nematode management.

Unit VI

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

Practical

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

Suggested Readings

- Dropkin VH.1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.
- Maggenti A R.1981.*General Nematology*. Springer-Verlag, NewYork.
- Perry R N and Moens M. 2013. *Plant Nematology*. 2nd Ed. CABI Publishing: Wallingford, UK. Perry R N, Moens Mand Starr J. L. 2009. *Root-knot Nematodes*, CABI Publishing: Wallingford, UK.
- Thorne G.1961. *Principles of Nematology*. McGraw Hill, New Delhi.

- Walia R K and Bajaj H K. 2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.
- Walia R K. and Khan M R. 2018. *A Compendium of Nematode Diseases of Crop Plants*, ICAR-AICRP (Nematodes), IARI, New Delhi.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Characteristics of Phylum Nematoda and its relationship with other related phyla.	01
2.	History and growth of Nematology; Nematode habitats and diversity- plant, animal and human parasites.	02
3.	Economic importance of Nematodes to agriculture, horticulture and forestry.	02
4.	Gross morphology of plant parasitic Nematodes.	01
5.	Broad classification, Nematode biology, physiology and ecology.	03
6.	Types of parasitism; nature of damage and general symptomatology.	03
7.	Interaction of plant-parasitic Nematodes with other organisms.	02
8.	Plant Nematode relationships, cellular responses to infection by important phyto Nematodes.	02
9.	Physiological specialization among phyto Nematodes.	02
10.	Principles and practices of Nematode management; integrated Nematode management.	03
11.	Emerging Nematode problems.	02
12.	Importance of Nematodes in international trade and quarantine.	03
Total		26

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Studies on kinds of Nematodes -free- living, animal, insect and plant parasites.	4
2.	Nematode extraction from soil.	1
3.	Extraction of migratory endoparasites.	2
4.	To study the plant succession in different types of forests.	2
5.	To study the stand form, growth and stand density in major forest of the locality.	2
6.	Staining for sedentary endoparasites.	2

7. Examination of different life stages of important plant parasitic Nematodes, their symptoms and histopathology.	2
Total	15

Course No.	Course Title	Credit Hrs.
NEM 502	Principles of Taxonomy	2+0

Objective

To sensitize the students on the theory and practice of classifying organisms and the rules governing the same.

Theory

Unit I

Introduction to history and principles of systematic and importance. Levels and functions of systematics. Identification, purpose, methods-character matrix, taxonomic keys. Descriptions-subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intra-specific variation in characters, polythetic and polymorphictaxa, sexual dimorphism.

Unit II

Classification of animals: Schools of classification-Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.

Unit III

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.

Suggested Reading

- Blackwelder RE. 1967. *Taxonomy – A Text and Reference Book*. John Wiley & Sons, New York.
- Kapoor VC. 1983. *Theory and Practice in Animal Taxonomy*. Oxford & IBH, New Delhi.
- Mayr E. 1971. *Principles of Systematic Zoology*. Tata McGraw-Hill, New Delhi.
- Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Black i.e, London.

Lecture Schedule

Theory

Sr.	Topic	No. of
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No.		Lecture (s)
1.	Introduction to history and principles of systematic and importance. Levels and functions of systematics	01
2.	Levels and functions of systematics. Identification, purpose, methods-character matrix, taxonomic keys.	01
3.	Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intra-specific variation in characters, polythetic and polymorphictaxa, sexual dimorphism.	02
4.	Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification.	01
5.	Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.	03
6.	Nomenclature: Common vs Scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names.	03
7.	Categories of names under consideration of ICZN.	01
8.	Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes.	02
Total		14

Practical : Nil

Course No.	Course Title	Credit Hrs.
NEM 503	Structural and Functional Organization of Nematodes	2+1

Objective

Familiarization with structural organization of nematode body so as to enable the students to understand biology, physiology and classification of nematodes.

Theory

Unit I

Introduction and general organization of nematode body; Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom.

Unit II

Digestive system-Structural variations of stoma, oesophagus, intestine and rectum in nematodes.

Unit III

Reproductive system-Variations in female and male reproductive systems, types of reproduction, spermatogenesis and oogenesis.

Unit IV

Types and structure of excretory-secretory systems; nervous system and associated sense organs.

Unit V

Embryogenesis, Cell lineage and post embryonic development; Process of hatching and moulting.

Practical

1. Studies on variations in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, oesophagus, rectum;
2. Types and parts of female and male reproductive systems, sense organs and excretory system.

Suggested Reading

- Bird AF and Bird J. 1991. *The Structure of Nematodes*. Academic Press, New York.
- Chitwood BG and Chitwood MB. 1950. *An Introduction to Nematology*. Univ. Park Press, Baltimore.
- Maggenti AR. 1981. *General Nematology*. Springer-Verlag, New York.
- Malakhov VV. 1994. *Nematodes: Structure, Development, Classification and Phylogeny*. Smithsonian Institution Press, Washington DC.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture (s)
1.	Introduction and general organization of nematode body	01
2.	Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom	02
3.	Digestive system-Structural variations of stoma, oesophagus, intestine and rectum in nematodes.	02
4.	Reproductive system-Variations in female and male reproductive systems,	01
5.	Types of reproduction, spermatogenesis and oogenesis.	01
6.	Types and structure of excretory-secretory systems; nervous system and associated sense organs.	03
7.	Embryogenesis, Cell lineage and post embryonic development; Process of hatching and moulting.	03
Total		13

Practical

Sr. No.	Topic	No. of Practical (s)
1	Studies on variations in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, oesophagus, rectum;	4

2. Types and parts of female and male reproductive systems, sense organs and excretory system.	4
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Total	8
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Course No.	Course Title	Credit Hrs.
NEM 504	Nematode Systematics	2+1

Objective

Understanding concepts in nematode taxonomy, development of skills in the identification of plant parasitic nematodes upto genera and species levels.

Theory

Unit I

Gross morphology, principles of nematode taxonomy -levels of taxonomy, systematics vs. taxonomy, morpho-taxonomy, molecular taxonomy, identification, classification, taxonomic categories, taxonomic characters, morphometry, Zoological nomenclature, species concept and speciation (allopatric and sympatric).

Unit II

Taxonomic position of nematodes and their relationships with allied groups; Classification and diagnoses of nematodes up to ordinal rank (Secernentea and Adenophorea)

Unit III

Taxonomy of free living nematodes

Unit IV

Classification of plant parasitic nematodes; Order Tylenchida and diagnoses of its sub-orders, super families, families and important genera; Order Aphelenchida, Dorylaimida and Triplonchida and diagnoses of their important genera.

Practical

1. Collection of soil and plant samples from different habitats, processing and preservation of samples; and preparation of temporary mounts, processing of nematode specimens and permanent mounts;
2. Preparation of en face view and TS of nematodes, perineal pattern of root knot nematodes and cone-top structure for cyst nematodes;
3. Identification of soil and plant nematodes from nematode suspension and mounted slides;
4. Camera lucida drawing of nematodes, measurement of nematodes using traditional as well as image analyzing software;
5. Procedures for PCR- Taxonomy.

Suggested Reading

- Ahmad W and Jairajpuri MS. 2010. *Mononchida: The Predatory Soil Nematodes, Series: Nematology Monographs and Perspectives*, Volume: 7, Brill.
- Geraert E. 2006. *Tylenchida*. Brill.

- Hunt DJ. 1993. *Aphelenchida, Longidoridae and Trichodoridae – their Systematics and Bionomics*. CABI, Wallingford.
- Jairajpuri MS and Ahmad W. 1992. *Dorylaimida: Free-Living, Predaceous and Plant-Parasitic Nematodes*, Brill.
- Mai WF, Mullin PG, Lyon HH and Loeffler K. 1996. *Plant-Parasitic Nematodes: A Pictorial Key to Genera*, 5th ed., Cornell University Press, London.
- Siddiqi MR. 2000. *Tylenchida: Parasites of Plants and Insects*. 2nd Ed. CABI, Wallingford.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Gross morphology, principles of nematode taxonomy - levels of taxonomy, systematics vs. taxonomy, morpho-taxonomy, molecular taxonomy,	03
2.	Identification, classification, taxonomic categories, taxonomic characters, morphometry,	02
3.	Zoological nomenclature, species concept and speciation (allopatric and sympatric).	02
4.	Taxonomic position of nematodes and their relationships with allied groups	02
5.	Classification and diagnoses of nematodes up to ordinal rank (Secernentea and Adenophorea)	02
6.	Taxonomy of free living nematodes	02
7.	Classification of plant parasitic nematodes; Order Tylenchida and diagnoses of its sub-orders, super families, families and important genera; Order Aphelenchida, Dorylaimida and Triplonchida and diagnoses of their important genera.	04
Total		17

Practical

Sr. No.	Topic	No. of Practical (s)
1	Collection of soil and plant samples from different habitats, processing and preservation of samples	4
2.	Preparation of temporary mounts, processing of nematode specimens and permanent mounts	4
3.	Preparation of en face view and TS of nematodes, perineal pattern of root knot nematodes and cone-top structure for cyst nematodes	2
4.	Identification of soil and plant nematodes from nematode suspension and mounted slides	2

5. Camera lucida drawing of nematodes, measurement of nematodes using traditional as well as image analyzing software	1
6. Procedures for PCR- Taxonomy	1

Total	14
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Course No.	Course Title	Credit Hrs.
NEM 505	Techniques in Nematology	1+2

Objective

Understanding the principles, theoretical aspects and developing skills in nematological techniques.

Theory

Unit I

Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipments.

Unit II

Survey and surveillance methods; collection of soil and plant samples; techniques for extraction of nematodes from soil and plant material; estimation of population densities.

Unit III

Killing, fixing, clearing and mounting nematodes; measurements, preparation of perineal patterns, vulval cones of cyst nematodes, en-face views and body section of nematodes.

Unit IV

In-vitro and in vivo culturing techniques of plant parasitic, bacteriophagous, mycophagous and omnivorous nematodes.

Unit V

Staining nematodes in plant tissues; microtomy for histopathological studies; collection of plant root exudates and their bioassay; preparation of plant materials for exhibition.

Unit VI

Application of molecular techniques in nematology.

Practical

1. Collection of soil and plant samples.
2. Extraction of nematodes from soil by Baermann's funnel, sieving and decanting, elutriation and sugar centrifugal methods.
3. Extraction of cysts from soil.
4. Extraction of nematodes from plant material.
5. Estimation of population densities.
6. Staining plant material for nematodes;
7. Killing and fixing nematodes, clearing nematodes by slow and Seinhorst's methods.
8. Preparation of temporary and permanent mounts.
9. Measurements, drawing, microphotography, special preparation of nematodes – perineal patterns, vulval cones, en-face and body sections.
10. Collection of root exudates, preparation of exhibits of nematode diseased plant material, in-vitro culturing techniques of nematodes- callous culture, excised root and carrot disc techniques.

Suggested Reading

- Ayoub SM. 1981. *Plant Nematology – An Agricultural Training Aid*.
- Barker KR, Carter CC and Sasser JN. 1985. *An Advanced Treatise on Meloidogyne*. Vol. II. *Methodology*. International *Meloidogyne* Project, NCSU, Raleigh. USA.
- Manzanilla-Loípez, RH and Marbain-Mendoza N. 2012. *Practical Plant Nematology*, Montecillo, Texcoco: Biblioteca Basica de Agricultura.
- Sikora RA, Coyne D, Hallman J and Timper P. 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*. 3rd edn. CABI Publishing, England.
- Southey JF. 1986. *Laboratory Methods for Work with Plant and Soil Nematodes*. HMSO, London.
- Subbotin SA, Mundo-Ocampo M and Baldwin J. 2010. *Systematics of The Genus Heterodera in Systematics of Cyst Nematodes (Nematoda: Heteroderinae)*, Part B, Series: Nematology Monographs and Perspectives, Volume: 8B, Brill.
- Zuckerman BM, Mai WF and Harrison MB. 1985. *Plant Nematology Laboratory Manual*. Univ. : Massachusetts.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture (s)
1.	Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipments.	02
2.	Survey and surveillance methods.	02
3.	Collection of soil and plant samples.	02
4.	Techniques for extraction of nematodes from soil and plant material.	01
5.	Estimation of population densities	01
6.	Killing, fixing, clearing and mounting nematodes;	01
7.	Measurements, preparation of perineal patterns.	02
8.	Vulval cones of cyst nematodes, en-face views and body section of nematodes	01
Total		12

Practical

Sr. No.	Topic	No. of Practical (s)
1	Collection of soil and plant samples; Extraction of nematodes from soil by Baermann's funnel, sieving and decanting, elutriation and sugar centrifugal methods; Extraction of cysts from soil;	02
2.	Extraction of nematodes from plant material;	01
3.	Estimation of population densities;	01
4.	Staining plant material for nematodes;	01
5.	Killing and fixing nematodes, clearing nematodes by slow and Seinhorst's methods; Preparation of temporary and permanent mounts;	02

6. Measurements, drawing, microphotography, special preparation of nematodes – perineal patterns, vulval cones, en-face and body sections;	02
7. Collection of root exudates,	01
8. Preparation of exhibits of nematode diseased plant material, <i>in-vitro</i> culturing techniques of nematodes- callous culture, excised root and carrot disc techniques	02
Total	12

Course No.	Course Title	Credit Hrs.
NEM 506	Nematode Diseases of Crops	2+1

Objective

To impart basic knowledge about the causal organism, nature of damage, symptoms and control of nematode diseases of agricultural and horticultural crops.

Theory

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops.

Unit I

Cereal crops- Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum.

Unit II

Pulses, Sugar, Fibre, Fodder and Oilseed crops- Pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugarbeet cyst and soybean cyst nematode problems.

Unit III

Vegetable crops- root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. nematode problems of protected cultivation.

Unit IV

Fruit crops- root-knot nematode, reniform nematode, slow decline of citrus. Flowers- root-knot nematode, foliar nematodes, bulb nematodes, Mushroom- nematode problems.

Unit V

Plantation, medicinal and aromatic crops- burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems of coffee and tea, red ring disease of coconut. Forests- Pine wilt disease.

Practical

1. Diagnosis of causal organisms.
2. Identification of different life cycle stages.
3. Study of symptoms and histopathology of nematode damage in different crops, study tours for field diagnosis of nematode problems.

Suggested Reading

- Bhatti DS and Walia RK. 1992. *Nematode Pests of Crops*. CBS, New Delhi.

- Bridge J and Starr JL. 2007. *Plant Nematodes of Agricultural Importance: A Colour Handbook*, CRC Press
- Evans AAF, Trudgill DL and Webster JM. 1994. *Plant Parasitic Nematodes in Temperate Agriculture*. CABI, Wallingford.
- Nickle WR. 1991. *Manual of Agricultural Nematology*. Marcel Dekker, New York.
- Perry RN and Moens M. 2006. *Plant Nematology*. CABI, Wallingford.
- Perry RN, Moens M and Jones JT. 2018. *Cyst Nematodes*, CABI Publishing: Wallingford, UK.
- Perry RN, Moens M and Starr JL. 2009. *Root-knot nematodes*, CABI Publishing: Wallingford, UK.
- Sikora R, Coyne D, Hallmann J and Timper P. 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*, 3rd Ed., CABI, UK.
- Walia RK and Khan MR. 2018. *A Compendium of Nematode Diseases of Crop Plants*, ICAR AICRP (Nematodes), IARI, New Delhi.

Lecture Schedule

Theory

Sr. No	Topic	No. of Lecture (s)
1.	Cereal crops- Ear-cockle and <i>tundu</i> diseases of wheat, <i>molya</i> disease of wheat and barley	01
2.	Rice root nematode, rice root-knot and cyst nematode problems, <i>ufra</i> and white tip diseases of rice;	01
3.	Lesion nematodes, cyst nematodes of maize and sorghum.	01
4.	Pulses, Sugar, Fibre, Fodder and Oilseed crops- Pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugarbeet cyst and soybean cyst nematode problems	03
5.	Vegetable crops- root-knot disease, reniform nematode, potato cyst nematode, stem and bulb nematode	02
6.	Nematode problems of protected cultivation.	02
7.	Fruit crops- root-knot nematode, reniform nematode, slow decline of citrus.	02
8.	Flowers- root-knot nematode, foliar nematodes, bulb nematodes,	01
9.	Mushroom- nematode problems.	01
Total		14

Practical

Sr. No.	Topic	No. of Practical (s)
1	Diagnosis of causal organisms; Identification of different life cycle stages;	04
2.	Study of symptoms and histopathology of nematode damage in different crops, Study tours for field diagnosis of nematode problems.	04
Total		08

Course No.	Course Title	Credit Hrs.
NEM 507	Nematode Biology and Physiology	2+1

Objective

To develop understanding of life cycle patterns, feeding and metabolic processes in phytonematodes which have implications in their management.

Theory**Unit I**

Host finding and invasion, feeding, hatching, moulting; life cycle patterns in different types of nematodes.

Unit II

Types of reproduction, gametogenesis, embryogenesis and post embryogenesis.

Unit III

Chemical composition of nematodes, hydrolytic enzymes, pseudocoelom and function of transport.

Unit IV

Physiology of digestive system, intermediary metabolism.

Unit V

Osmoregulation, physiology of excretory-secretory and neuromuscular systems.

Practical

1. Studies on embryogenesis and post-embryogenesis, hatching, moulting, life cycle development, feeding, enzymatic assay by electrophoresis.

Suggested Reading

- Croll NA. 1970. *The Behaviour of Nematodes: The Activity, Senses and Responses*. Edward Arnold, London.
- Croll NA and Mathews BE. 1977. *Biology of Nematodes*. Blackie, Glasgow. Lee DL. 2002. *The Biology of Nematodes*. Taylor & Francis, London.
- Lee DL and Atkinson HJ. 1976. *Physiology of Nematodes*. MacMillan, London.
- Perry RN and Wright DJ. 1998. *The Physiology and Biochemistry of Free-living and Plant Parasitic Nematodes*. CABI, Wallingford.
- Wallace HR. 1963. *The Biology of Plant Parasitic Nematodes*. Edward Arnold, London.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture (s)
1.	Host finding and invasion, feeding, hatching, moulting; life cycle patterns in different types of nematodes.	04
2.	Types of reproduction, gametogenesis, embryogenesis and post embryogenesis.	02
3.	Chemical composition of nematodes, hydrolytic enzymes, pseudocoelom and function of transport.	02

4. Physiology of digestive system, intermediary metabolism.	02
5. Osmoregulation, physiology of excretory-secretory and neuromuscular systems.	02
Total	12

Practical

Sr. No.	Topic	No. of Practical(s)
1.	Studies on embryogenesis and post-embryogenesis, hatching, moulting, life cycle development, feeding, enzymatic assay by electrophoresis.	08
Total		08

Course No.	Course Title	Credit Hrs.
NEM 508	Nematode Ecology	2+1

Objective

To understand the life of plant parasitic nematodes in their environment; their survival strategies, and how to exploit these for their control.

Theory**Unit I**

Definition and scope; components of environment; evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.

Unit II

Role of nematodes in the food web; habitat and niche characteristics; community analysis and population estimation models.

Unit III

Effects of abiotic and biotic factors on nematodes.

Unit IV

Environmental extremes and nematode behaviour- aggregation, swarming, orientation, feeding and reproduction.

Unit V

Survival strategies of nematodes in adverse environment and absence of host.

Unit VI

Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.

Practical

1. Study of nematode fauna in varied agro-ecological systems.
2. Community analysis of nematode populations.
3. Laboratory exercises on influence of abiotic factors on movement and hatching, green-house experiments on effect of abiotic factors on nematode populations and plant growth.

Suggested Reading

- Croll NA. 1970. *The Behaviour of Nematodes: The Activity, Senses and Responses*. Edward Arnold, London.
- Croll NA and Mathews BE. 1977. *Biology of Nematodes*. Blackie, Glasgow. Lee DL. 2002. *The Biology of Nematodes*. Taylor & Francis, London.
- Gaugler R and Bilgrami AL. 2004. *Nematode Behaviour*, CABI, UK.
- Norton DC. 1978. *Ecology of Plant Parasitic Nematodes*. John Wiley. Poinar G. 1983. *Natural History of Nematodes*. Prentice Hall, Englewood Cliffs.
- Wallace HR. 1973. *Nematode Ecology and Plant Disease*. Edward Arnold, London.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture (s)
1.	Definition and scope; components of environment	01
2.	Evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.	02
3.	Role of nematodes in the food web; habitat and niche characteristics;	01
4.	Community analysis and population estimation models.	01
5.	Effects of abiotic and biotic factors on nematodes.	01
6.	Environmental extremes and nematode behavior - aggregation, swarming, orientation, feeding and reproduction.	02
7.	Survival strategies of nematodes in adverse environment and absence of host.	01
8.	Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.	02
Total		11

Practical

Sr. No.	Topic	No. of Practical (s)
1	Study of nematode fauna in varied agro-ecological systems	02
2.	Community analysis of nematode populations	02
3.	Laboratory exercises on influence of abiotic factors on movement and hatching	02
4.	Green-house experiments on effect of abiotic factors on nematode populations and plant growth.	02
Total		08

Course No.	Course Title	Credit Hrs.
NEM 509	Nematode Interactions with Other Organisms	2+1

Objective

To understand the role of nematodes in disease complexes involving fungal, bacterial, viral and other organisms.

Theory**Unit I**

Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms.

Unit II

Interaction of plant parasitic nematodes with wilt causing fungal pathogens and micro fungi.

Unit III

Interaction of plant parasitic nematodes with root rot and other fungal pathogens.

Unit IV

Interaction of plant parasitic nematodes with bacterial pathogens, other nematode species and arthropods.

Unit V

Virus transmission by nematodes.

Practical

1. Green-house experiments to study the role of plant parasitic nematodes in wilt/ rot causing fungal and bacterial pathogens.

Suggested Reading

- Khan MW. 1993. *Nematode Interactions*. Chapman & Hall, New York.
- Lamberti F, Taylor CE and Seinhorst JW. 1975. *Nematode Vectors of Plant Viruses*. Plenum Press, London.
- Mondia JL and Timper P. 2016. Interactions of microfungi and plant parasitic nematodes. In: *Biology of Microfungi* (De-Wei-Lei Ed.). Springer Publications
- Sasser JN and Jenkins WR. 1960. *Nematology: Fundamentals and Recent Advances with Emphasis on Plant Parasitic and Soil Forms*. Eurasia Publ. House, New Delhi.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture(s)
1.	Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms	01
2.	Interaction of plant parasitic nematodes with wilt causing fungal pathogens and micro fungi.	02

3.	Interaction of plant parasitic nematodes with root rot and other fungal pathogens.	02
4.	Interaction of plant parasitic nematodes with bacterial pathogens, other nematode species and arthropods.	02
5.	Virus transmission by nematodes	01
Total		08

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Green-house experiments to study the role of plant parasitic nematodes in wilt/rot causing fungal and bacterial pathogens.	06
Total		06

Course No.	Course Title	Credit Hrs.
NEM 510	Nematode Management	2+1

Objective

To impart comprehensive knowledge about the principles and practices of nematode management.

Theory

Unit I

Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.

Unit II

Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.

Unit III

Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil, bio-fumigation, antagonistic and trap crops, sanitation, etc. Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material.

Unit IV

Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods – use of antagonistic plants and antinemaic plant products.

Unit V

Genetic methods- plant resistance; legal methods- quarantine regulations; integrated nematode management- concepts and applications.

Practical

1. In-vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods;
2. Methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on biocontrol potential of fungal, bacterial parasites, and predacious fungi and nematodes.

Suggested Reading:

- Bhatti DS and Walia RK. 1994. *Nematode Pest Management in Crops*. CBS, New Delhi.
- Brown GL. 1977. *The Nematode Destroying Fungi*. CBP, Guelph.
- Brown RH and Kerry BR. 1987. *Principles and Practice of Nematode Control in Crops*. Academic Press, Sydney.
- Chen ZX, Chen SY and Dickson DW. 2004. *Nematology: Advances and Perspectives. Vol. II. Nematode Management and Utilization*. CABI, Wallingford.
- Perry RN and Moens M. 2013. *Plant Nematology*. 2nd Ed., CABI, Wallingford, London.
- Starr JL, Cook R and Bridge J. 2002. *Plant Resistance to Parasitic Nematodes*. CABI, Wallingford.
- Stirling GR. 2014. *Biological Control of Plant parasitic Nematodes*, 2nd Ed., CAB International, UK.
- Whitehead AG. 1997. *Plant Nematode Control*. CABI, Wallingford.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture (s)
1.	Concepts and history of nematode management; crop loss estimation,	01
2.	Ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.	02
3.	Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.	02
4.	Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil, bio-fumigation, antagonistic and trap crops, sanitation, etc. Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material.	01
5.	Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods – use of antagonistic plants and antinemaic plant products.	02
6.	Genetic methods- plant resistance; legal methods- quarantine regulations	02
7.	Integrated nematode management- concepts and applications.	01
Total		11

Practical

Sr. No.	Topic	No. of Practical (s)
1.	<i>In-vitro</i> screening of synthetic chemicals and plant products for nematicidal activity, and their application methods	04
2.	Methods for screening of crop germplasm for resistance against nematodes.	02

3. Laboratory exercises on biocontrol potential of fungal, bacterial parasites, and predacious fungi and nematodes	03
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Total	09
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Course No.	Course Title	Credit Hrs.
NEM 511	Beneficial Nematodes	1+1

Objective

To sensitize about the use of nematodes for the biological control of insect pests of crops, and application of some nematodes as biological models and as indicators of environmental pollution.

Theory

Unit I

Beneficial nematode fauna – predators, parasites of insects, molluscs and other pests; Entomophilic nematodes- important groups, types of nematode- insect associations; taxonomic characteristics of nematode parasites of insects.

Unit II

Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids.

Unit III

Entomopathogenic nematodes- *Steinernema*, *Heterorhabditis*, *Oscheius* their morphological characteristics, taxonomic status, biology and mode of action.

Unit IV

Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.

Unit V

Nematodes as biological models, nematodes as indicators of pollution, role of nematodes in organic matter recycling.

Practical

1. Isolation, identification, mass rearing and application methods of entomopathogenic nematodes.

Suggested Reading:

- Gaugler R and Kaya HK. 1990. *Entomopathogenic Nematodes in Biological Control*. CRC Press, Boca Raton, Florida.
- Gaugler R. 2002. *Entomophilic Nematology*. CABI, Wallingford.
- Grewal PS, Ehlers RU and Shapiro DI. 2005. *Nematodes as Biocontrol Agents*. CABI, Wallingford.
- Jairajpuri MS and Khan MS. 1982. *Predatory Nematodes (Mononchida)*. Associated Publ. Co., New Delhi.
- Wood WB. 1998. *The Nematode Caenorhabditis elegans*. Cold Spring Harbor Press.
- Woodring JL and Kaya HK. 1988. *Steinernematid and Heterorhabditid Nematodes: A Handbook of Techniques*. Southern Coop. Bull., Ark. Ag. Ext. Sta.
- Zuckerman BM. (Ed.). 1980. *Nematodes as Biological Models*. Vols. I, II. Academic Press, New York.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Beneficial nematode fauna – predators, parasites of insects, molluscs and other pests;	01
2.	Entomophilic nematodes- important groups, types of nematode- insect associations	02
3.	Taxonomic characteristics of nematode parasites of insects.	01
4.	Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids.	02
5.	Entomopathogenic nematodes- <i>Steinernema</i> , <i>Heterorhabditis</i> , <i>Oscheius</i> their morphological characteristics, taxonomic status, biology and mode of action.	02
6.	Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.	02
7.	Nematodes as biological models, nematodes as indicators of pollution, role of nematodes in organic matter recycling.	02
Total		12

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Isolation, identification, mass rearing and application methods of entomopathogenic nematodes.	08
Total		08

Course No.	Course Title	Credit Hrs.
NEM 512/ ENT 510	Principles of Integrated Pest Management	1+1

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

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

Suggested Reading:

- Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*.
- Plant Protection–Nematology, Kalyani Publishers, New Delhi.
- Dhaliwal GS, Ram Singh and Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publishers, New Delhi. Flint MC and Bosch RV. 1981. *Introduction to Integrated Pest Management*. 1st Ed., Springer, New York.
- 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.
- Metcalf RL and Luckman WH. 1982. *Introduction of Insect Pest Management*. John Wiley & Sons, New York.
- Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.
- Pedigo RL. 2002. *Entomology and Pest Management*. 4th Ed. Prentice Hall, New Delhi.
- Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	History and origin, definition and evolution of various related terminologies.	02
2.	Concept and philosophy, ecological principles, economic threshold concept and economic consideration.	02
3.	Tools of pest management and their integration- legislative, cultural, physical and mechanical methods	02
4.	Pest survey and surveillance, forecasting, types of surveys including	01

	remote sensing methods, factors affecting surveys; political, social and legal implications of IPM	
5.	Pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting case studies of successful IPM programmes.	02
Total		09

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Characterization of agro-ecosystems	01
2.	Sampling methods and factors affecting sampling	01
3.	Population estimation methods	01
4.	Crop loss assessment- direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses	01
5.	Computation of EIL and ETL;	01
6.	Crop modeling; designing and implementing IPM system	02
Total		07

Course No.	Course Title	Credit Hrs.
NEM 513/ PL PATH 513	Disease Resistance in Plants	2+0

Objective

To acquaint with disease resistance mechanisms in plants.

Theory**Unit I**

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.

Unit II

Disease escape, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Unit III

Host defense system, morphological and anatomical resistance, preformed chemicals in host defense, post infectious chemicals in host defense, phytoalexins hypersensitivity and its mechanisms.

Unit IV

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Suggested Reading

- Dallice M *et al.* 1996. *Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction*. APS, St Paul, Minnesota.
- Deverall, B.J. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, New York.
- Parker J. 2008. *Molecular Aspects of Plant Diseases Resistance*. Blackwell Publ.
- Robinson RA. 1976. *Plant Pathosystems*. Springer Verlag, New York. Singh BD. 2005. *Plant Breeding – Principles and Methods*. 7th Ed. Kalyani Publishers, Ludhiana.
- Van der Plank JE. 1975. *Principles of Plant Infection*. Academic Press, New York.
- Van der Plank JE. 1978. *Genetic and Molecular Basis of Plant Pathogenesis*. Springer Verlag, New York.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture(s)
1.	Introduction and historical development.	01
2.	Dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology	02
3.	Disease escape, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.	02
4.	Identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.	02
5.	Host defense system, morphological and anatomical resistance, preformed chemicals in host defense, post infectious chemicals in host defence, phytoalexins hypersensitivity and its mechanisms.	02
Total		09

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.	08
Total		08

Course No.	Course Title	Credit Hrs.
NEM 514/ ENT 520	Plant Quarantine, Biosafety and Biosecurity	2+0

Objective

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory

Unit I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.

Unit II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Unit III

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

Unit IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Reading

- Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.
- Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.
- Shukla A and Veda OP. 2007. *Introduction to Plant Quarantine*. Samay Prakashan, New Delhi.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Definition of pest, pesticides and transgenics as per Govt. notification;	01
2.	Relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.	02
3.	Plant protection organization in India.	01
4.	Acts related to registration of pesticides and transgenics.	01
5.	History of quarantine legislations, PQ Order 2003.	01
6.	Environmental Acts, Industrial registration; APEDA, Import and Export of	02

	bio-control agents.	
7.	Identification of pest/ disease free areas; contamination of food with toxigens	01
8.	Microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestations/ salvaging of infected material.	02
9.	WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry	01
10.	Sanitary and Phytosanitary measures.	01
Total		13

Practical : Nil

Course No.	Course Title	Credit Hrs.
NEM 515/ PATH 521/ ENT 524	IPM in Protected Cultivation	2+1

Objective

To sensitize the pest and disease scenario developing in crops raised under protected cultivation and to impart knowledge about the remedy.

Theory

Unit I

Characteristics of protected cultivation and tools for sustainable crop production; outline of major biotic stresses in protected cultivation including: fungi, bacteria, virus, nematode, insects and mites.

Unit II

Sampling and monitoring pests and diseases; epidemiology and damage relationships; loss assessment; population dynamics of biotic stress agents; factors responsible for severity of pests and diseases.

Unit III

Host plant resistance to pathogens and insects; management strategies for protected cultivation: disinfestation of soil and growth media; preventive, scouting and early detection; and curative measures: biological control of sap sucking pests, leaf miners; soil- and air-borne pathogens; pesticides selectivity, applications and resistance management; buzz pollination.

Practical

1. Visit to familiarize with pest and disease situations developing in protected cultivation.
2. Symptomatology and damages; identification of the causes; estimation of population densities; management tactics/ approaches and recommendations; production and commercialization of biological agents.

Suggested Reading:

- Gullino ML, Albajes, R and Nicot P. 2019. *Integrated Pest and Disease Management in Greenhouse Crops*. Ed. 2nd, Springer, New York.
- Rathee *et al.* 2018. Integrated Pest Management under Protected Cultivation—A Review.
- *Journal of Entomology and Zoology Studies*, 6 (2): 1201–1208.

Lecture Schedule

Theory		
Sr. No.	Topic	No. of Lecture (s)
1.	Characteristics of protected cultivation and tools for sustainable crop production;	01
2.	Outline of major biotic stresses in protected cultivation including: fungi, bacteria, virus, nematode, insects and mites.	02
3.	Sampling and monitoring pests and diseases; epidemiology and damage relationships; loss assessment; population dynamics of biotic stress agents	02
4.	Factors responsible for severity of pests and diseases.	01
5.	Host plant resistance to pathogens and insects.	01
6.	Management strategies for protected cultivation: disinfection of soil and growth media; preventive, scouting and early detection; and curative measures:.	02
7.	Biological control of sap sucking pests, leaf miners; soil- and air-borne pathogens; pesticides selectivity, applications and resistance management; buzz pollination	02
Total		11

Practical		
Sr. No.	Topic	No. of Practical(s)
1.	Visit to familiarize with pest and disease situations developing in protected cultivation	04
2.	Symptomatology and damages; identification of the causes; estimation of population densities; management tactics/ approaches and recommendations; production and commercialization of biological agents.	04
Total		08

Learning outcome: Students are expected to be well versed with the crop pest and disease problems associated with protected cultivation and their management

List of Journals

- *Annals of Applied Nematology* – Society of Nematologists, USA
- *Current Nematology* – Bioved Research Society, Allahabad, India
- *Egyptian Journal of Agronomatology* – Egyptian Society of Agricultural Nematology
- *Indian Journal of Nematology* – Nematological Society of India
- *International Journal of Nematology* – Afro-Asian Society of Nematologists, Luton
- *Japanese Journal of Nematology* – Japanese Nematological Society
- *Journal of Nematology* – Society of Nematologists, USA
- *Journal of Nematode Morphology and Systematics* – Jaen, Universidad de Jaen
- *Nematologia Brasileira* – Brazilian Nematological Society
- *Nematologia Mediterranea* – Istituto per la Protezione delle Plante (IPP) – Sect. of

Bari of the CNR, Italy

- *Nematology* – EJ Brill Academic Publishers, UK
- *Nematropica* – Organization of Nematologists of Tropical America
- *Pakistan Journal of Nematology* – Pakistan Society of Nematologists
- *Russian Journal of Nematology* – Russian Society of Nematologists

e-Resources

<http://www.nematologists.org/> (The Society of Nematologists)

<http://nematology.ucdavis.edu/> (Deptt. of Nematology, Univ. of California, Davis)

<http://www.ifns.org/> (International Federation of Nematology Societies)

<http://www.inaav.ba.cnr.it/nemmed.html> (Nematologia Mediterranea)

<http://nematode.unl.edu/Nemajob.htm> (Nematology Employment Bulletin Board)

<http://nematode.unl.edu/> (University of Nebraska – Lincoln Nematology)

<http://nematode.unl.edu/wormsite.htm> (Links to Other Nematology Resources)

<http://nematode.unl.edu/SON/jon.htm> (Journal of Nematology)

<http://www.nematology.ucr.edu/> (Deptt. of Nematology, Univ. of California, Riverside)

<http://entnemdept.ifas.ufl.edu/> (Univ. of Florida, Entomology and Nematology Dept.)

http://www.brill.nl/m_catalogue_sub6_id8548.htm (Nematology – journal)

http://www.ars.usda.gov/main/site_main.htm?modecode=12752900 (Nematology Lab., USDA)

http://flnem.ifas.ufl.edu/history/nem_history.htm (Nematology history)

<http://www.nematology.ugent.be/> (Nematology Unit, Ghent University)

<http://www.entm.purdue.edu/nematology/> (The Purdue Nematology Lab.)

<http://www.bspp.org.uk/ppigb/nematolo.htm#a-z> (Links to Nematology labs)

<http://www.nem.wur.nl/UK/> (Laboratory of Nematology, Wageningen Univ.)

<http://onta.ifas.ufl.edu/> (The Organization of Nematologists of Tropical America)

http://www.openj-gate.org/Articlelist.asp?Source=1&Journal_ID=103267. (Nematology Newsletter)

<http://nematology.umd.edu/nematology.html> (Plant Nematology Laboratory, Maryland)

<http://www.biology.leeds.ac.uk/nem/> (Plant Nematology Lab., University of Leeds)

<http://www.plantpath.iastate.edu/dept/labs/tylka/> (Iowa State University, Nematology Lab)

<http://nematologists.org.au/newsletters.html> (Australasian Association of Nematologists)

<http://soilplantlab.missouri.edu/nematode/> (Plant Nematology Laboratory, Missouri)

<http://www.eumaine.ugent.be/> (European Master of Science in Nematology)

<http://www.jstage.jst.go.jp/browse/jjn> (The Japanese Journal of Nematology)

Course Contents

Ph.D. in Nematology

Course No.	Course Title	Credit Hrs.
NEM 601	Nematode Phylogeny and Systematics	2+1

Objective

Concepts in Systematics, understanding nematode diversity, evaluation and analysis of taxonomic characters for inferring interrelationships among nematode groups, modern methods and tools for identification of nematodes and phylogenetic analysis.

Theory

Unit I

Phylogenetic systematics – Evolutionary systematics, Cladistics, phylogenetic trends (morphological) and molecular phylogenetic framework for the phylum nematoda, phylogenomics

Unit II

Taxonomic characters, numerical taxonomy, morphometry, variations, statistics in taxonomic descriptions, description of new species, preparation of illustrations, keys and compendia for nematode species.

Unit III

Identification of common species of root knot nematodes by esterase phenotypes and race/ pathotypes of root knot/ cyst/ reniform nematodes by differential host tests.

Unit IV

Recent advances in nematode identification- molecular, biochemical, immunodiagnostic, molecular characterization and DNA finger-printing techniques.

Practical

1. Detailed studies of morphological structures and identification of plant parasitic nematodes up to species level.
2. Preparation of compendia and keys.
3. Drawing and measurements using camera lucida and computer software.
4. Procedures for identification of species/ races of root-knot/ cyst/ reniform nematodes.
5. Isozyme analysis for identification of common species of root knot nematodes. rDNA- RFLP for diagnosis of nematode species.
6. Sequence analysis, alignment, phylogenetic analysis, preparation of phylogenetic tree and interpretation.

Suggested Reading:

- Andraissy I. 1976. *Evolution as a basis for the systematization of nematodes*. Pitman Publishing Ltd, London.
- Blackwelder RE. 1967. *Taxonomy – A Text and Reference Book*. John Wiley & Sons, New York.
- Plant Protection–Nematology Chen ZX, Chen SY and Dickson DW. 2004. *Nematology: Advances and Perspectives. Vol. I*.
- *Nematode Morphology, Physiology and Ecology*. CABI, Wallingford.
- Fortuner R. 1988. *Nematode Identification and Expert System Technology*. NATO Science Series A:

Springer US.

- Geraert E. 2006. *Nematology Monographs and Perspectives*. Vol. IV. EJ. Brill.
- Kapoor VC. 1983. *Theory and Practice in Animal Taxonomy*. Oxford & IBH, New Delhi.
- Mayr E. 1969. *Principles of Systematic Zoology*. Tata McGraw-Hill, New Delhi.
- Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie, London.
- Stone AR, Platt HM and Khalil LF. 1983. *Concepts in Nematode Systematics, the Systematics Association Special Volume No. 22*, Academic Press, London and NY.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Phylogenetic systematics – Evolutionary systematics, Cladistics, phylogenetic trends (morphological) and molecular phylogenetic framework for the phylum nematoda, phylogenomics	03
2.	Taxonomic characters, numerical taxonomy, morphometry, variations, statistics in taxonomic descriptions, description of new species,.	02
3.	Preparation of illustrations, keys and compendia for nematode species	02
4.	Identification of common species of root knot nematodes by esterase phenotypes and race/ pathotypes of root knot/ cyst/ reniform nematodes by differential host tests.	03
5.	Recent advances in nematode identification- molecular, biochemical, immunodiagnostic	01
6.	Molecular characterization and DNA finger-printing techniques.	03
Total		14

Practical

Sr. No.	Topic	No. of Practical(s)
1	Detailed studies of morphological structures and identification of plant parasitic nematodes up to species level;	02
2.	Preparation of compendia and keys	02
3.	Drawing and measurements using camera lucida and computer software;	02
4.	Procedures for identification of species/ races of root-knot/ cyst/ reniform nematodes.	01
5.	Isozyme analysis for identification of common species of root knot nematodes. rDNA- RFLP for diagnosis of nematode species;	02
6.	Sequence analysis, alignment, phylogenetic analysis, preparation of phylogenetic tree and interpretation.	02
Total		11

Course No.	Course Title	Credit Hrs.
NEM 602	Nematode Disease Development and Host Resistance	2+1

Objective

To update knowledge on their current search trends in the field of plant nematode relationships at genetic and molecular level.

Theory**Unit I**

Mechanisms of pathogenesis, cytological and biochemical changes induced by nematode feeding.

Unit II

Plant defense systems, role of phytoalexins, etc. against major plant parasitic nematodes.

Unit III

Genetic basis of plant resistance to nematodes and identification of resistance genes against economically important nematodes.

Unit IV

Application of biotechnological methods in the development of nematode resistant crop cultivars; resistance markers; incorporation of resistance by conventional breeding and transgenic approaches.

Unit V

Influence of microorganisms on plant nematode interactions.

Practical

1. Microtomy for study of histopathological changes induced by important nematodes, screening techniques for assessment of resistance in crop germplasm against nematodes.

Suggested Reading:

- Barker KR, Pederson GA and Windham GL. 1998. *Plant and Nematode Interactions*. CABI, Wallingford.
- Fenoll C, Grundler FMW and Ohl SA. 1997. *Cellular and Molecular aspects of Plant-Nematode Relationships*. Kluwer Academic Press, Dordrecht.
- Lamberti F, Giorgi C and Bird D. 1994. *Advances in Molecular Plant Nematology*. Plenum Press.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture(s)
1.	Mechanisms of pathogenesis, cytological and biochemical changes induced by nematode feeding.	02
2.	Plant defense systems, role of phytoalexins, etc. against major plant parasitic nematodes.	02
3.	Genetic basis of plant resistance to nematodes.	01
4.	Identification of resistance genes against economically important nematodes	01
5.	Application of biotechnological methods in the development of nematode	02

resistant crop cultivars; resistance markers; incorporation of resistance by conventional breeding and transgenic approaches.

6. Influence of microorganisms on plant nematode interactions. 02

Total 10

Practical

Sr. No.	Topic	No. of Practical (s)
1	Microtomy for study of histopathological changes induced by important nematodes	04
2.	Screening techniques for assessment of resistance in crop germplasm against nematodes	04
Total		08

Course No.	Course Title	Credit Hrs.
NEM 603	Advances in Nematode Management	2+1

Objective

To keep abreast with latest developments and trends in nematode management.

Theory

Unit I

Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- predacious and parasitic fungi; nematotoxic fungal culture filtrates.

Unit II

Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- parasitic and nematode antagonistic bacteria; predacious mites and predacious nematodes.

Unit III

Mass culturing, formulation, quality control, bio-safety and registration protocols of bio-control agents.

Unit IV

Phytoalexins, allelochemicals, phytotherapeutic substances, novel nematocides, deployment of resistant varieties and non-host crops in nematode suppressive cropping systems, emergence of resistance breaking biotypes, recent regulatory provisions and methods, quarantine and disinfection.

Unit V

Nematode management modules for integrated pest and disease management in cropping systems. nematode management options and approaches for organic farming, precision farming and protected cultivation system. Application of GIS and GPS technology for surveillance and management.

Practical

1. Green-house experiments on the efficacy of fungal and bacterial bio-control agents, botanicals.

Suggested Reading

- Chen ZX, Chen SY and Dickson DW. 2004. *Nematology: Advances and Perspectives Vol. II. Nematode Management and Utilization*. CABI, Wallingford.
- Jana BL. 2008. *Precision Farming*. Research Books and Periodicals Pvt. Ltd., Delhi.
- Lillesend TW, Kiefer RW and Chipman JW. 1979. *Remote Sensing and Image Interpretation*. John Wiley & Sons, New York.
- Perry RN and Moens M. 2013. *Plant Nematology*. 2nd Ed., CABI, Wallingford, London.
- Poinar GO Jr and Jansson H-B. 1988. *Diseases of Nematodes*. Vols. I, II. CRC Press, Boca Raton, Florida. Scientific Publ., Jodhpur.
- Starr JR, Cook R and Bridge J. 2002. *Plant Resistance to Parasitic Nematodes*. CABI, Wallingford.
- Stirling GR. 2014. *Biological Control of Plant parasitic Nematodes*, 2nd Ed., CAB International, UK.
- Tarafdar JC, Priputhi KP and Kumar M. 2007. *Organic Agriculture*. Upadhyaya RK, Walia RK and Dubey OP. 2004. *IPM Systems in Agriculture. Vol. IX. Phytonematology*. Aditya Books, New Delhi.

Lecture Schedule**Theory**

Sr. No.	Topic	No. of Lecture(s)
1.	Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- predacious and parasitic fungi; nematotoxic fungal culture filtrates.	02
2.	Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- parasitic and nematode antagonistic bacteria; predacious mites and predacious nematodes.	02
3.	Mass culturing, formulation, quality control, bio-safety and registration protocols of bio-control agents.	02
4.	Phytoalexins, allelochemicals, phytotherapeutic substances, novel nematicides, deployment of resistant varieties and non-host crops in nematode suppressive cropping systems, emergence of resistance breaking biotypes,	02
5.	Recent regulatory provisions and methods, quarantine and disinfection.	01
6.	Nematode management modules for integrated pest and disease management in cropping systems.	01
7.	Nematode management options and approaches for organic farming, precision farming and protected cultivation system..	01
8.	Application of GIS and GPS technology for surveillance and management	01
Total		12

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Green-house experiments on the efficacy of fungal and bacterial bio-control agents, botanicals.	08
Total		08

Course No.	Course Title	Credit Hrs.
NEM 604	Physiological and Molecular Nematology	2+1

Objective

Appraisal on the application of modern biotechnological tools in nematology.

Theory

Unit I

Cell biology- Structural and functional aspects; genetics and evolution in plant parasitism in nematodes.

Unit II

Caenorhabditis elegans- a model system for gerontology, cytogenetics, physiology, nutritional, toxicological and pharmacological studies; Heterodera glycines as a model for biology, proteomic and genomic studies.

Unit III

Chemoreception, neurobiology, and biochemical basis of communication in nematodes, molecular basis of host recognition, nematode-Associated Molecular Patterns (NAMPs), molecular pathways of plant-nematode interaction.

Unit IV

Biochemical, genetical and molecular basis of plant nematode interaction; histopathological, cellular and molecular changes in host feeding cells, resistance genes, genome editing, sequencing of genome, Transcriptome and Proteome analysis of plant parasitic nematodes, RNAi technology

Unit V

Biochemical and molecular basis of survival strategies in nematodes, molecular mechanism of host resistance against plant parasitic nematodes, molecular and novel approaches for nematode management.

Practical

1. Isolation and quantification of proteins from nematode juveniles and eggs.
2. Molecular weight determination of nematode protein.
3. Buffer preparation for molecular techniques, PCR, α -esterase polymorphism in root-knot nematode
4. Nematode DNA isolation from juveniles and eggs.
5. RFLP of nematode DNA.
6. Nematode DNA amplification using PCR for nematode identification, RNAi technology.

Suggested Reading:

- Chen ZX, Chen SY and Dickson DW. 2004. *Nematology: Advances and Perspectives. Vol. I.*

- *Nematode Morphology, Physiology and Ecology*. CABI, Wallingford.
- Fenoll C, Grundler FMW and Ohl SA. 1997. *Cellular and Molecular aspects of Plant-Nematode Relationships*. Kluwer Academic Publ., Dordrecht.
- Gommers EJ and Maas PW. 1992. *Nematology from Molecule to Ecosystem*. European Soc. of Nematologists.
- Lamberti F, Giorgi C and Bird D. 1994. *Advances in Molecular Plant Nematology*. Plenum Press.
- Perry RN and Wright DJ. 1998. *The Physiology and Biochemistry of Free- living and Plant Parasitic Nematodes*. CABI, London.
- Riddle DL. 1997. *C. elegans II*. Cold Spring Harbor Press.
- Wood WB. 1988. *The Nematode Caenorhabditis elegans*. Cold Spring Harbor Press, US.
- Zuckerman BM. 1980. *Nematodes as Biological Models*. Vols. I, II. Academic Press, New York.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture(s)
1.	Cell biology- Structural and functional aspects; genetics and evolution in plant parasitism in nematodes.	01
2.	<i>Caenorhabditis elegans</i> - a model system for gerontology, cytogenetics, physiology, nutritional, toxicological and pharmacological studies	02
3.	<i>Heterodera glycines</i> as a model for biology, proteomic and genomic studies	01
4.	Chemoreception, neurobiology, and biochemical basis of communication in nematodes, molecular basis of host recognition, nematode-Associated Molecular Patterns (NAMPs), molecular pathways of plant-nematode interaction.	02
5.	Biochemical, genetical and molecular basis of plant nematode interaction; histopathological, cellular and molecular changes in host feeding cells, resistance genes, genome editing, sequencing of genome, Transcriptome and Proteome analysis of plant parasitic nematodes, RNAi technology	03
6.	Biochemical and molecular basis of survival strategies in nematodes,	01
7.	Molecular mechanism of host resistance against plant parasitic nematodes, molecular and novel approaches for nematode management.	02
Total		12

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Isolation and quantification of proteins from nematode juveniles and eggs;	01

2. Molecular weight determination of nematode protein;	01
3. Buffer preparation for molecular techniques, PCR, α -esterase polymorphism in root-knot nematode;	02
4. Nematode DNA isolation from juveniles and eggs;	02
5. RFLP of nematode DNA	02
6. Nematode DNA amplification using PCR for nematode identification, RNAi technology	02
Total	10

Course No.	Course Title	Credit Hrs.
NEM 605/ PL PATH 606	Plant Biosecurity and Biosafety	2+0

Objective

To facilitate deeper understanding of plant biosecurity and biosafety issues in agriculture.

Theory

Unit I

History of biosecurity, concept of biosecurity, components of biosecurity, Quarantine, Invasive Alien Species, biowarfare, emerging/ resurgence of pests and diseases.

Unit II

National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/ World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Unit III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

Suggested Reading:

- Biosecurity: A Comprehensive Action Plan.
- Biosecurity Australia.
- Biosecurity for Agriculture and Food Production.
- FAO Biosecurity Toolkit 2008.
- Grotto Andrew J and Jonathan B Tucker. 2006. Biosecurity Guidance.
- Khetarpal RK and Kavita Gupta. 2006. Plant Biosecurity in India – Status and Strategy. Asian Biotechnology and Development Review 9(2): 3963.

- Randhawa GJ, Khetarpal RK, Tyagi RK and Dhillon. BS (Eds.). 2001. Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.

e-Resources

<http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.shtml>

www.fao.org/docrep/010/a1140e/a1140e00.htm Laboratory

http://www.who.int/csr/resources/publications/biosafety/WHO_CD_S_EPR_2006.pdf

http://www.americanprogress.org/kf/biosecurity_a_comprehensive_action_plan.pdf

www.biosecurity.govt.nz DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm

www.daff.gov.au/ba; www.affa.gov.au/biosecurityaustralia Biosecurity New Zealand.

<http://www.fao.org/biosecurity/> CFIA.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture(s)
1.	History of biosecurity, concept of biosecurity, components of biosecurity, Quarantine, Invasive Alien Species, biowarfare, emerging/ resurgence of pests and diseases.	02
2.	National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/ World Trade Organization (WTO), Convention on Biological Diversity (CBD),	03
3.	International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity,	02
4.	Pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.	02
Total		09

VII. List of Journals

- *Annals of Applied Nematology* – Society of Nematologists, USA
- *Current Nematology* – Bioved Research Society, Allahabad, India
- *Egyptian Journal of Agronematology* – Egyptian Society of Agricultural Nematology
- *Indian Journal of Nematology* – Nematological Society of India
- *International Journal of Nematology* – Afro-Asian Society of Nematologists, Luton
- *Japanese Journal of Nematology* – Japanese Nematological Society
- *Journal of Nematology* – Society of Nematologists, USA
- *Journal of Nematode Morphology and Systematics* – Jaen, Universidad de Jaen
- *Nematologia Brasileira* – Brazilian Nematological Society
- *Nematologia Mediterranea* – Istituto per la Protezione delle Plante (IPP) – Sect. of Bari of the CNR, Italy

- *Nematology* – EJ Brill Academic Publishers, UK
- *Nematropica* – Organization of Nematologists of Tropical America
- *Pakistan Journal of Nematology* – Pakistan Society of Nematologists
- *Russian Journal of Nematology* – Russian Society of Nematologists

e-Resources

<http://www.nematologists.org/> (The Society of Nematologists)
<http://nematology.ucdavis.edu/> (Deptt. of Nematology, Univ. of California, Davis)
<http://www.ifns.org/> (International Federation of Nematology Societies)
<http://www.inaav.ba.cnr.it/nemmed.html> (Nematologia Mediterranea)
<http://nematode.unl.edu/Nemajob.htm> (Nematology Employment Bulletin Board)
<http://nematode.unl.edu/> (University of Nebraska – Lincoln Nematology)
<http://nematode.unl.edu/wormsite.htm> (Links to Other Nematology Resources)
<http://nematode.unl.edu/SON/jon.htm> (Journal of Nematology)
<http://www.nematology.ucr.edu/> (Deptt. of Nematology, Univ. of California, Riverside)
<http://entnemdept.ifas.ufl.edu/> (Univ. of Florida, Entomology and Nematology Dept.)
http://www.brill.nl/m_catalogue_sub6_id8548.htm (Nematology – journal)
http://www.ars.usda.gov/main/site_main.htm?modecode=12752900 (Nematology Lab., USDA)
http://flnem.ifas.ufl.edu/history/nem_history.htm (Nematology history)
<http://www.nematology.ugent.be/> (Nematology Unit, Ghent University)
<http://www.entm.purdue.edu/nematology/> (The Purdue Nematology Lab.)
<http://www.bspp.org.uk/ppigb/nematolo.htm#a-z> (Links to Nematology labs)
<http://www.nem.wur.nl/UK/> (Laboratory of Nematology, Wageningen Univ.)
<http://onta.ifas.ufl.edu/> (The Organization of Nematologists of Tropical America)
http://www.openj-gate.org/Articlelist.asp?Source=1&Journal_ID=103267. (Nematology Newsletter)
<http://nematology.umd.edu/nematology.html> (Plant Nematology Laboratory, Maryland)
<http://www.biology.leeds.ac.uk/nem/> (Plant Nematology Lab., University of Leeds)
<http://www.plantpath.iastate.edu/dept/labs/tylka/> (Iowa State University, Nematology Lab)
<http://nematologists.org.au/newsletters.html> (Australasian Association of Nematologists)
<http://soilplantlab.missouri.edu/nematode/> (Plant Nematology Laboratory, Missouri)
<http://www.eumaine.ugent.be/> (European Master of Science in Nematology)
<http://www.jstage.jst.go.jp/browse/jjn> (The Japanese Journal of Nematology)

**Revision and Implementation of Masters and
Doctoral Program's Syllabi in the SAUs of
Maharashtra as per Recommendation of
ICAR – NCG – BSMA**

MASTERS AND DOCTORAL DEGREE

in

PLANT PATHOLOGY

**BSMA Syllabus of Post Graduate
Programmes – 2022-23**

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Dr. K.T. Apet
Discipline Coordinator
Plant Pathology

**Preamble
(Plant Protection – Plant Pathology)**

The National Core Grant was constituted by ICAR for development of Academic Regulation for Masters and Ph.D. programme. On the recommendations of the National Core Grant, 19 Broad Subject Matter Area (BSMA) Committees were constituted for revising the syllabus. For Plant Protection Dr. S. Lingaraju was the Chairman and Dr. A.K. Bhowmick was the Convener.

The BSMA Committee on Plant Protection meticulously deliberated upon the issues to ameliorate the overall agricultural education programme and Plant Protection in particular. The Curricula and Syllabi of the Master's and Ph.D. Agri. in Plant Pathology were discussed in the meetings convened by the Broad Subject Coordinator, Discipline coordinator and Course leader. The opinion and suggestions invited from experts in all four Agricultural Universities in Maharashtra were reviewed by the committee.

The modified post graduate programme in Plant Protection particularly Plant Pathology has been designed to meet out the demands of Private Sector, advanced research and application, Supplementary Practical Skill required and to enhance national and global competence and employability of our students.

In Plant Pathology discipline two Master's programme courses have been deleted, *viz.*, Mushroom Production Technology and Insect Vectors of Plant Viruses and other Pathogens. The erstwhile nomenclature of the (masters and doctoral) courses on Bacteria is changed to 'Plant Pathogenic Prokaryotes' and 'Advances in Plant Pathogenic Prokaryotes', respectively. Since the exploitation of Botanicals for the pathogens' suppression and the disease management is gaining ground, the aspects pertaining to them find a place in a course. A course on Plant Nematology is added and made compulsory at master's level.

The Master's and Doctoral programmes retain the fundamental aspects e.g. morphology, taxonomy, physiology, biology/bionomics and ecology besides covering the applied aspects of beneficial microorganism be they (nematodes, fungi and bacteria), their commercial utilization, disease spectrum of specific crop and their management. Various current issues and latest approaches in the subject of Plant Pathology have been given a new thrust. Aiming at improving the theoretical and practical knowledge of the post graduate students. At the doctoral level emphasis has been given to research work.

Some of the salient features of the revised curriculum at the Master's level include emphasis on molecular approaches and nanotechnology in Plant Pathology; understanding host plant resistance and breeding for disease resistant crop cultivars; ecological for disease management in conventional, protected cultivation and organic farming systems; besides an independent course on integrated management of disease situations (diseases and nematodes) in protected cultivation; independent, enhancing farm income; detailed study on post-harvest losses due to plant disease and their management; an elaborate exposure to plant quarantine, biosafety and bio-security in view of the rising invasive disease and repercussions of climate change. These aspects have been included in the Master's curriculum itself keeping in view of the invasive, exotic pathogen and disease records as also with a view to cover the details of Indian Biodiversity Act. At the Doctoral level, the coverage of different courses both theoretical and practical, has been reduced with a view to enable the scholars concentrate on their research work towards achieving significant transferable technologies.

Two online meetings of all Heads of Plant Pathology in four Agril. Universities of Maharashtra along with staff teaching to PG subjects was held to finalize the modification of syllabi. As per decisions in the meeting held Some new Books are added in respective subjects. It has been again suggested that the PG Teacher should

be well acquainted to the recent advances and developments in the subject and it should be incorporated in the subject.

The reader of this note can see that this preamble is meant to give a bird's eye view about our BSMA Committee's recommendations *vis-a-vis* the discipline of Plant Pathology. The Courses at a Glance provided at the beginning of discipline will instantly tell the changes from the previous dispensation of 2009 (the first BSMA effort). There is no gain saying the fact that the syllabi of each course may be consulted for a larger use.

Committee on Plant Pathology

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' SubCommittees)	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Plant Protection	Plant Pathology	M.Sc. (Ag)	Ph.D.	Dr. C.S. Patil Head Department of Entomology, MPKV, Rahuri	Dr. K.T. Apet, Head (Plant Pathology) VNMKV., Parbhani Email: hodppvnmkv@Gmail.com

Implementation of New Curriculum

The universities offering PG programmes in Plant Pathology need to be supported for establishing specialised laboratories equipped with state-of-the-art equipments for conducting practical classes especially, Molecular Approaches in Plant Pathology.

One-time catch-up grant should be awarded to each SAU, offering PG programmes in Plant Pathology for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under a SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in discipline of Plant Pathology in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Sc. and Ph.D. Programmes in Plant Pathology will be considered at par with the recommended M.Sc. & Ph.D. programme by Vth Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Plant Pathology throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M.Sc.: 4 Semesters

Ph.D.: 6 Semesters

Name of the Departments / Divisions

- Plant Protection: Plant Pathology

Nomenclature of Degree Programme
(a) M.Sc. Programmes

- i) M.Sc. (Agri.) in Plant Pathology

(b) Ph. D. Programmes

- i) Ph.D. (Agri.) in Plant Pathology

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 500/600 series courses as well as research topics.
- Lecture schedule and practical schedule has also been given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Credit Requirements

Course Details	Master's Degree	Doctoral Degree
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02

Research	30	75
Total	70	100

**M.Sc. (Ag.) Plant Pathology
Course Structure**

**LIST OF CORE COURSES/ DEPARTMENT WISE SPECIALIZATION/
COMPULSORY/SUPPORTING COURSE**

1. M.Sc. (Ag.) Plant Pathology

Course Code	Term	Course Title	Credit Hrs.
PL PATH 501*	I	Mycology	2+1
PL PATH 502*	I	Plant virology	2+1
PL PATH 503*	II	Plant pathogenic Prokaryotes	2+1
PL PATH 504*	III	Plant Nematology	2+1
PL PATH 505*	I	Principles of Plant Pathology	2+1
PL PATH 506*	II	Techniques in Detection & Diagnosis of Plant Diseases	0+2
PL PATH 507	II	Principles of Plant Disease Management	2+1
PL PATH 508	II	Epidemiology and forecasting of Diseases	1+0
PL PATH 509	I	Disease Resistance in Plants	2+0
PL PATH 510	II	Ecology of Soil Borne Pathogens	1+1
PL PATH 511	I	Chemicals & Botanicals in Plant Disease Management	2+1
PL PATH 512	I	Detection & Management of Seed Borne Pathogens	2+1
PL PATH 513	II	Biological control of Plant Diseases	1+1
PL PATH 514	I	Integrated Disease Management	2+1
PL PATH 515*	I	Diseases of Field & Medicinal crops	2+1
PL PATH 516	II	Diseases of Fruits, Plantation & Ornamental crops	2+1
PL PATH 517	I	Diseases of Vegetable & Spices Crops	2+1
PL PATH 518	I	Post-Harvest Diseases	2+1
PL PATH 519	I	Plant Quarantine & Regulatory Methods	1+0
PL PATH 591	III	Master's Seminar	0+1
		Total	32+18=60
PL PATH 599		Master's Research	0+30

* Compulsory Courses

2. Common Courses: (Non-Credit)

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1
PGS 502	I	Technical Writing and Communications Skills	0+1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0
PGS 504	II	Basic Concepts in Laboratory Techniques	0+1
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	III	Disaster Management	1+0

Optional/Supporting Courses:

Course Code	Semester	Course Title	Credit Hrs.
STAT 502		Statistical Methods for Applied Sciences	2+1
STAT 511		Experimental Designs	2+1
STAT 521		Applied Regression Analysis	2+1
BIOCHEM 501		Basic Biochemistry	3+1
BIOCHEM 505		Techniques in Biochemistry	2+2
MCA 512		Information Technology in Agriculture	1+1

1. Statistics
2. Biochemistry
3. Information Technology

(Note: The above courses are been offered by various disciplines (The list is only indicative based on the requirement any of the above courses may be opted under the supporting courses). The Syllabi of these courses are available in the respective disciplines. If required the contents may be modified to suit the individual discipline with approval of the concerned BOS).

Minor Disciplines:

1. Agronomy
2. Agril Entomology
3. Agril. Botany
4. Biotechnology
5. Horticulture
6. Plant Physiology
7. Microbiology
8. Agril. Chemistry and Soil Science
9. Agril. Extention
10. Agril Economics

Compulsory Non-Credit Deficiency Courses
(Those who are non-Agriculture and Horticulture Graduates)

Course Code	Semester	Course Title	Credit Hrs.
PL PATH-411		Fundamentals of Plant Pathology	2+1=3
PL PATH-412		Principles of Integrated Disease Management	1+1=2
PL PATH-413		Diseases of Field and Horticulture crops and Their Management-I	2+1=3
PL PATH-414		Diseases of Field and Horticulture crops and Their Management-II	2+1=3

Semester Layout

M.Sc. Agriculture (Plant Pathology)

Sem. No.	Course No.	Title of Course	Credits
I	PL. PATH.501*	Mycology	2+1=3
	PL. PATH.502*	Plant Virology	2+1=3
	PL. PATH.505*	Principles of Plant Pathology	2+1=3
	PL PATH 509	Disease Resistance in Plants	2+0=2
	PL PATH 512	Detection & Management of Seed Borne Pathogens	2+1=3
	PL PATH 514	Integrated Disease Management	2+1=3
	PL PATH 517	Diseases of Vegetable & Spices Crops	2+1=3
	PL PATH 518	Post-Harvest Diseases	2+1=3
	PL PATH 519	Plant Quarantine & Regulatory Methods	1+0=1
II	PL PATH 503*	Plant Pathogenic Prokaryotes	2+1=3
	PL. PATH.506*	Techniques in Detection & Diagnosis of Plant diseases	0+2=2
	PL PATH 515*	Diseases of Field & Medicinal crops	2+1=3
	PL PATH 507	Principles of Plant Disease Management	2+1=3
	PL PATH 508	Epidemiology and forecasting of Diseases	1+0=1
	PL PATH 510	Ecology of Soil Borne Pathogens	1+1=2
	PL PATH 513	Biological control of Plant Diseases	1+1=2
	PL PATH 516	Diseases of Fruits, Plantation & Ornamental crops	2+1=3
PL PATH 511	Chemicals & Botanicals in Plant Disease Management	2+1=3	
III	PL. PATH.507*	Plant Nematology	2+1=3
	PL. PATH.591	Master's Seminar	0+ 1=1
	PL. PATH.599	Master Research	0+30=30
IV	PL. PATH.599	Master Research	

* Compulsory courses,

Major -20, Minor -08, Supporting -06, Seminar-01 and Common courses-06, Thesis – 30 Total 70

(Recent Advances should be included in all courses time to time)

Course Title: Mycology

II. Course Code: PI PATH 501

III. Credit Hours: 2+1

IV. Aim of the course

To study the nomenclature, classification and characters of fungi.

V. Theory

Unit I

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.

Unit II

The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

Unit III

Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.

Unit IV

Basidiomycota; general characters, mode of reproduction, types of basidioearps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

Classification of Fungi according to Krik 2008

VI. Practical

- Detailed comparative study of different groups of fungi;
- Collection of cultures and live specimens;
- Saccardoan classification and classification based on eonidiogenesis;
- Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi;
- Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia. Oomyeota;
- Somatic and reproductory structures of *Pythium*, *Phytophthora*, downy mildews and *Albugo*, Zygomycetes: Sexual and asexual structures of *Mucor*, *Rhizopus*, General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales, and Eurotiales;
- General identification characters of Pyrenomycetes, Discomycetes, Loculo- ascomyeetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastruetures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes;
- Characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi;
- Application of molecular approaches and techniques for identification of fungal pathogens

Teaching Schedule

Theory

Lecture No.	Topic	Weightages (Percent)
1-2	Introduction to Fungi and basic concepts	20-26
3-4	Definition of different terms	
5-6	Importance of mycology in agriculture, relation of fungi to human affairs including lichen, mushrooms and other beneficial fungi	

7-8	Historical developments of mycology	
9	Importance of culture collection and herbarium of fungi	
10-11	Somatic characters, Reproduction genetic variability in fungi	
12-13	Modern concept of nomenclature and Classification of fungi	
14-15	Classification of kingdom fungi: Stramenopila, Protists and fungal diversity	
16-20	The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota.	20-30
21-25	The general characteristics of Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota	
26-28	Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.	30-32
29-32	Basidiomycota; general characters, mode of reproduction, types of basidioearps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.	30-32
	Total	100-120

Practical

Sr. No.	P. no	Topic
1	1-2	Detailed comparative study of different groups of fungi
2	3-4	Collection of cultures and live specimens
3	5-6	Saccardoan classification and classification based on conidiogenesis
4	7-8	Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi
5	9-10	Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia. Oomycota
6	11-12	Somatic and reproductory structures of <i>Pythium</i> , <i>Phytophthora</i> , downy mildews and <i>Albugo</i> , Zygomycetes: Sexual and asexual structures of <i>Mucor</i> , <i>Rhizopus</i> , General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales, and Eurotiales
7	13-14	General identification characters of Pyrenomycetes, Discomycetes, Loculo- ascomycetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes
8	15-16	Characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi
9	17-18	Application of molecular approaches and techniques for identification of fungal pathogens

VII. Suggested Reading

- Ainsworth GC, Sparrow FK and Susman HS. 1973. *The Fungi - An Advanced Treatise*. Vol. IV(A & B). Academic Press, New York.
- Alexopoulos CJ, Mims CW and Blackwell M. 2000. *Introductory Mycology*. 5th Ed. John Wiley & Sons, New York.
- Maheshwari R. 2016. *Fungi - Experimental Methods in Biology* 2nd edn. CRC Press, US. Mehrotra RS and Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi. Sarbhoy AK. 2000. *Test hook of Mycology*. ICAR, New Delhi.
- Singh RS. 1982. *Plant Pathogens - The Fungi*. Oxford & IBH, New Delhi.
- Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

Course Title: Plant Virology**II. Course Code: PI PATH 502****III. Credit Hours: 2+1****IV. Aim of the course**

To acquaint with the structure, virus- vector relationship, biology and management of plant viruses.

v. Theory**Unit I**

History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions. Origin and evolution of viruses and their nomenclature and classification.

Unit II

Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatically changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

Unit III

Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.

Unit IV

Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival). Management of diseases caused by plant viruses.

VI. Practical

- Study of symptoms caused by plant viruses (followed by field visit);
- Isolation and biological purification of plant virus cultures;
- Bioassay of virus cultures on indicator plants and host differentials
- Transmission of plant viruses (Mechanical, graft and vector and study of disease development)
- Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology;
- Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR—LAMP, Later flow micro array and PCR based techniques);
- Exposure to basic bio-informatie tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Clustal X/W, MEGA Software).

Teaching schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-8	History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions. Origin and evolution of viruses and their nomenclature and classification	20-25
9-16	Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatic changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.	30-35
17-20	Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.	30-35
21-30	Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival). Management of diseases caused by plant viruses.	20-25
	Total	100-120

Practical

Sr. No.	P. no	Topic
1	1-2	Study of symptoms caused by plant viruses (followed by field visit)
2	3-4	Isolation and biological purification of plant virus cultures
3	5-6	Bioassay of virus cultures on indicator plants and host differentials
4	7-8	Transmission of plant viruses (Mechanical, graft and vector and study of disease development)
5	9-10	Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology
6	11-12	Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR—LAMP, Later flow micro array and PCR based techniques)
7	13-14	Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Clustal X/W, MEGA Software).

VII. Suggested Reading

- Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.
- Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ and Watson L. 1995. *Virus of Plants. - Descriptions and Lists from VIDE Database*. CABI, Wallington.
- Gibbs A and Harrison B. 1976. *Plant Virology — The Principles*. Edward Arnold, London. Hull R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.
- Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Oxford & IBH, New Delhi.
- Wilson C. 2014. *Applied Plant Virology*. CABI Publishing England.

Course Title: Plant Pathogenic Prokaryotes**II. Course Code: PI PATH 503****III. Credit Hours: 2+1****IV. Aim of the course**

To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional requirements, survival and dissemination.

v. Theory**Unit I**

Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and gram-positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccharide structure; Membrane transport; fimbriae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

Unit II

Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.

Unit III

Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

Unit IV

Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria- conjugation; transformation; transduction); and horizontal gene transfer.

Unit V

Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

VI. Practical

- Study of symptoms produced by phytopathogenic prokaryotes;
- Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria;
- Stains and staining methods;
- Biochemical and serological characterization;
- Isolation of genomic DNA plasmid;
- Use of antibacterial chemicals/ antibiotics;
- Isolation of fluorescent *Pseudomonas*,
- Preservation of bacterial cultures;
- Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences;
- Diagnosis and management of important diseases caused by bacteria and mollicutes.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-8	Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and gram-positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccharide structure; Membrane transport; fimbriae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S-layer; capsule); the bacterial chromosomes and	20-24

	plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.	
9-16	Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.	20-24
17-20	Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes	24-28
21-26	Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria- conjugation; transformation; transduction); and horizontal gene transfer	18-22
27-32	Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.	18-22
	Total	100-120

Practical

Sr. No.	P. No.	Topic
1	1-2	Study of symptoms produced by phytopathogenic prokaryotes
2	3-4	Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria
3	5-6	Stains and staining methods
4	7-8	Biochemical and serological characterization
5	9-10	Isolation of genomic DNA plasmid
6	11-12	Use of antibacterial chemicals/ antibiotics
7	13-14	Isolation of fluorescent <i>Pseudomonas</i>
8	15-16	Preservation of bacterial cultures
9	17-18	Identification of prokaryotic organisms by using 16S rDNA, and other genesequences
10	19-20	Diagnosis and management of important diseases caused by bacteria and mollicutes.

VII. Suggested Reading

- Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.
 Jayaraman I and Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publishers, Ludhiana.
 Mount MS and Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II Academic Press, New York.
 Salle AJ. 1979. *Fundamental Principles of Bacteriology T' edn*.
 Verma JP, Varma A and Kumar D. (Eds). 1995. *Detection of Plant Pathogens and their Management*.
 Angkor Pub1., New Delhi

Thind B S. 2012. *Phytopathogenic Prokaryotes and Plant Diseases*. Scientific Publications New Delhi

Course Title: Plant Nematology

II. Course Code: PI PATH 504

III. Credit Hours: 2+1

IV. Aim of the course

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

V. Theory

Unit I

Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

Unit III

Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

Unit V

Principles and practices of nematode management; integrated nematode management.

Unit VI

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

VI. Practical

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

Teaching Schedule

Theory

Lecture No	Topic	Weightages (Percent)
1-8	Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.	20-22
9-14	Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.	20-22
16-20	Types of parasitism, nature of damage and general symptomatology; interaction of plant parasitic nematodes with another organism.	20-22
20-26	Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.	15-20
27-30	Principles and practices of nematode management; integrated nematode management.	15-20
31-32	Emerging nematode problems, Importance of nematodes in international trade and quarantine	10-14
	Total	100-120

Practical

Sr. No.	P. No.	Topics
1	1-3	Studies on kinds of nematodes-free living, animal, insect and plant parasites
2	4-8	Nematode extraction from soil; extraction of migratory endoparasites
3	9-15	Extraction of migratory endoparasites, staining for sedentary endoparasites
4	16-18	Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

VII. Suggested Reading

- Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.
- Maggenti AR. 1981. *General Nematology*. Springer-Verlag, New York.
- Perry RN and Moens M. 2013. *Plant Nematology*. 2nd Ed. CABI Publishing: Wallingford, UK.
- Perry RN, Moens M, and Starr JL. 2009. *Root-knot nematodes*, CABI Publishing: Wallingford, UK.
- Sikora RA, Coyne D, Hallman J and Timper P. 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*. 3rd edn. CABI Publishing, England.
- Thorne G. 1961. *Principles of Nematology*. McGraw Hill, New Delhi.
- Walia RK and Bajaj HK. 2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.
- Walia RK and Khan MR. 2018. *A Compendium of Nematode Diseases of Crop Plants*, ICAR-AICRP (Nematodes), IARI, New Delhi.

Course Title: Principles of Plant Pathology

II. Course Code: PI PATH 505

III. Credit Hours: 2+1

IV. Aim of the course

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

V. 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; defence 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

Unit V

Disease Management strategies. Principles of Disease management. Role of plant quarantine regulations in India. Post entry quarantine. Role of Cultural methods, chemicals, Biopesticides and Bioagents, resistant varieties, biotechnology and its implication in management of plant diseases. Pesticide registration and label claims of fungicides.

VI. 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.

Teaching Schedule

Theory

Lecture No	Topic	Weightages (Percent)
1-10	Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases. Phytopathological Classics.	20-22
11-21	Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.	20-23
22-35	Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defence strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.	20-25
35-41	Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.	20-25
42-48	Disease Management strategies. Principles of Disease management. Role of plant quarantine regulations in India. Post entry quarantine. Role of Cultural methods, chemicals, Biopesticides and Bioagents, resistant varieties, biotechnology and its implication in management of plant diseases. Pesticide registration label claims of fungicides.	20-25
	Total	100-120

Practical

Sr. no.	P.no.	Topic
1	1-2	Basic plant pathological techniques
2	4-6	Isolation, inoculation and purification of plant pathogens and proving Koch's postulates
3	7-10	Techniques to study variability in different plant pathogens
4	10-13	Purification of enzymes, toxins and their bioassay
5	14-16	Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants

VII. Suggested Reading

Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.

Heitefuss 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.

Chaube H S and V S Pundhir .2009. Crop Diseases and Their Management. PHL Learning Pvt. LTD.New Delhi

Course Title: Techniques for Detection and Diagnosis of Plant Diseases**II. Course Code: PI PATH 506****III. Credit Hours: 0+2****IV. Aim of the course**

To impart training on various methods/ techniques/ instruments used in the study of plant diseases/ pathogens.

V. Practical

- Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens).
- 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid-based techniques (Non-PCR—LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.);
- Phenotypic and genotypic tests for identification of plant pathogens
- Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing;
- Volatile compounds profiling by using GC-MS and LC-MS;
- FAME analysis, Fluorescence *in-situ* Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens;
- Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

Practical

P. No.	Topic
1-6	Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid-based techniques (Non-PCR—LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.);
7-10	Phenotypic and genotypic tests for identification of plant pathogens;
11-16	Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing;
17-20	Volatile compounds profiling by using GC-MS and LC-MS
21-25	FAME analysis, Fluorescence <i>in-situ</i> Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens
26-30	Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

VI. Suggested Reading

- Baudoin ABAM, Hooper GR, Mathre DE and Carroll RB. 1990. *Laboratory Exercises in Plant Pathology. - An Instructional Kit*. Scientific Publ., Jodhpur.
- Dhingra OD and Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo. Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*, CABI Wallington. Forster D and Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods iii Molecular Biology*. Humana Press, Totowa, New Jersey.
- Mathers REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo. Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.
- Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agric. Pub.Doc. Wageningen.
- Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi. Trigiano RN, Windham MT and Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida. Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

Course Title: Principles of Plant Disease Management**II. Course Code: PI PATH 507****III. Credit Hours: 2+1****IV. Aim of the course**

To acquaint with different strategies for management of plant diseases.

V. Theory**Unit I**

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

Unit II

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.

Unit III

Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health cis-o-cis environmental hazards, residual effects and safety measures

VI. Practical

- Phytopathometry
- Methods of *in-vitro* evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Field evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Soil solarisation, methods of soil fumigation under protected cultivation;
- Methods of application of chemicals and bio control agents;
- ED and MIC values, study of structural details of sprayers and dusters;
- Artificial epiphytotic and screening of resistance.

Teaching Schedule**Theory**

Lecture No	Topic	Weightages (Percent)
1- 8	Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.	20-30
9-20	History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides	40-45
21-30	Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health cis-o-cis environmental hazards, residual effects and safety measures	40-45
	Total	100-120

Practical

Sr. No.	P. No	Topics
1	1-2	Phytopathometry
2	3-4	Methods of <i>in-vitro</i> evaluation of chemicals, antibiotics, bio agents against plant pathogens
3	5-6	Field evaluation of chemicals, antibiotics, bio agents against plant pathogens
4	7-8	Soil solarisation, methods of soil fumigation under protected cultivation
5	9-10	Methods of application of chemicals and bio control agents
6	11-12	ED and MIC values, study of structural details of sprayers and dusters
7	13-14	Artificial epiphytotic and screening of resistance

VII. Suggested Reading

- Fry WE. 1982. *Principles of Plant Disease Management*. Academic Press, New York.
- Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington. Marsh RW. 1972. *Systemic Fungicides*. Longman, New York.
- Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. Oxford & IBH, New Delhi.
- Palti S. 1981. *Cultural Practices and Infectious Crop Diseases*. Springer Verlag, New York. Vyas SC. 1993 *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

Course Title: Epidemiology and Forecasting of Plant Diseases**II. Course Code: PI PATH 508****III. Credit Hours: 1+0****IV. Aim of the course**

To acquaint with the principles of epidemiology and its application in disease forecasting.

V. Theory**Unit I**

Epidemic concepts, simple interest and compound interest disease, historical development. Elements of epidemics and their interaction. Structures and patterns of epidemics. Modelling, system approaches and expert systems in plant pathology.

Unit II

Genetics of epidemics. Models for development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics. Population biology of pathogens, temporal and spatial variability in plant pathogens.

Unit III

Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment.

Unit IV

Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting, some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction. Salient features of important forecasting models.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-4	Epidemic concepts, simple interest and compound interest disease, historical development. Elements of epidemics and their interaction. Structures and patterns of epidemics. Modelling, system approaches and expert systems in plant pathology.	20-25
5-8	Genetics of epidemics. Models for development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics. Population biology of pathogens, temporal and spatial variability in plant pathogens.	30-35
9-12	Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment	30-35
13-16	Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting, some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction. Salient features of important forecasting models.	20-25
Total		100-120

VI. Suggested Reading

Campbell CL and Madden LV. 1990. *Introduction to Plant Disease Epidemiology*. John Wiley & Sons, New York

Cooke B, Jones DM and Gereth KB. 2018 *The Epidemiology of Plant Diseases*. Springer Publications.

Cowling EB and Horsefall JG. 1978. *Plant Disease*. Vol. II. Academic Press, New York. Laurence VM, Gareth H and Frame Van den Bosch (Eds.). *The study of Plant Disease Epidemics*.

APS, St. Paul, Minnesota.

Nagaraj an S and Murlidharan K. 1995. *Dynamics of Plant Diseases*. Allied Publ., New Delhi.

Thresh JM. 2006. *Plant Virus Epidemiology*. Advances in Virus Research 67, Academic Press, New York.

Van der Plank JE. 1963. *Plant Diseases Epidemics and Control*. Academic Press, New York.

Zadoks JC and Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London.
S. Nagarajan 1983. *Plant Disease Epidemiology*. Pub: Oxford, IBN. Pub, New Delhi

Course Title: Diseases Resistance in Plants**II. Course Code: PI PATH 509****III. Credit Hours: 2+0****IV. Aim of the course****V. Theory****Unit I**

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escape, on-host resistance and disease tolerance.

Unit II

Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Unit III

Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defence, post infectious chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-9	Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escape, on-host resistance and disease tolerance.	20-30
10-18	Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.	40-45
19-30	Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defence, post infectious chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.	40-45
Total		100-120

VI. Suggested Reading

- Deverall BJ. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, New York.
- Mills Dallice *et al.* 1996. *Molecular Aspects of Pathogenicity and Resistance*. - Requirement for Signal Transduction. APS, St Paul, Minnesota.
- Parker J. 2008. *Molecular Aspects of Plant Diseases Resistance*. Blackwell Publ. Robinson RA. 1976. *Plant Pathosystems*. Springer Verlag, New York.
- Singh BD. 2005. *Plant Breeding — Principles and Methods*. 7th Ed. Kalyani Publishers, Ludhiana Van der Plank JE. 1975. *Principles of Plant Infection*. Academic Press, New York.
- Van der Plank JE. 1978. *Genetic and Molecular Basis of Plant Pathogenesis*. Springer Verlag. New York.
- Van der Plank JE. 1982. *Host Pathogen Interactions in Plant Disease*. Academic Press, New York.
- Van der Plank JE. 1984. *Disease Resistance in Plants*. Academic Press, New York.

Course Title: Ecology of Soil Borne Plant Pathogens**II. Course Code: PI PATH 510****III. Credit Hours: 1+1****IV. Aim of the course**

To provide knowledge on soil-plant disease relationship.

V. Theory**Unit I**

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Interaction of microorganisms.

Unit II

Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Conducive and suppressive soils.

Unit IIIBiological control- concepts and potentialities for managing soil borne pathogens. Potential of *Trichoderma* and fluorescent *Pseudomonas* in managing plant diseases.**VI. Practical**

- Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens;
- Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils;
- Suppression of test soil-borne pathogens by antagonistic microorganisms;
- Isolation and identification of different biocontrol agents;
- Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens;
- Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants;
- Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-8	Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Interaction of microorganisms.	20-30
9-12	Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Conducive and suppressive soils.	40-45
13-18	Biological control- concepts and potentialities for managing soil borne pathogens. Potential of <i>Trichoderma</i> and fluorescent <i>Pseudomonas</i> in managing plant diseases.	40-45
Total		100-120

Practical

Sr. No.	P. No.	Topics
1	1-2	Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens;
2	3-4	Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils
3	5-6	Suppression of test soil-borne pathogens by antagonistic microorganisms
4	7-8	Isolation and identification of different biocontrol agents
5	9-10	Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens
6	11-12	Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants
7	13-14	Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants

VII. Suggested Reading

- Baker KF and Snyder WC. 1965. *Ecology of soil-borne Plant Pathogens*. John Wiley, New York.
- Cook RJ and Baker KF. 1983. *The Nature and Practice of Biological Control of Plant Pathogens*. APS, St Paul, Minnesota.
- Garret SD. 1970. *Pathogenic Root -infection g Fungi*. Cambridge Univ. Press, Cambridge, NewYork.
- Hillocks RJ and Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CABI, Wallington.
- Mondia JL and Timper P 2016. Interactions of microfungi and plant parasitic nematodes. In: *Biology of Microfungi* (De-Wei-Let Ed.). Springer Publications
- Parker CA, Rovira AD, Moore KI and Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

I. Course Title: Chemicals and Botanicals in Plant Disease Management**II. Course Code: PI PATH 511****III. Credit Hours: 2+1****IV. Aim of the course**

To provide knowledge on the concepts, principles and judicious use of chemicals and botanicals in plant disease management.

V. Theory**Unit I**

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.

Unit II

Classification of chemicals used in plant disease management and their characteristics.

Unit III

Chemicals in plant disease control, viz., fungicides, bactericides, nematocides, antiviral chemicals and botanicals. Issues related to label claim.

Unit IV

Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

Unit V

Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides.

Unit VI

Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

VI. Practical

- . Acquaintance with formulation of different fungicides and plant protection appliances;
- Formulation of fungicides, bactericides and nematocides;
- *In-vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens;
- Persistence, compatibility with other agro-chemicals;
- Detection of naturally occurring fungicide resistant mutants of pathogen;
- Methods of application of chemicals.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-6	History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.	20-22
7-10	Classification of chemicals used in plant disease management and their characteristics.	20-22
11-14	Chemicals in plant disease control, viz., fungicides, bactericides, nematocides, antiviral chemicals and botanicals. Issues related to label claim.	20-22
15-18	Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.	15-20
19-22	Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides	15-20
22-28	Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.	10-14

	Total	100-120
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Practical

S. No.	P. no.	Topics
1	1-3	Acquaintance with formulation of different fungicides and plant protection appliances
2	4-8	Formulation of fungicides, bactericides and nematocides
3	9-11	<i>In- vitro</i> evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens
4	12-14	Persistence, compatibility with other agro-chemicals
5	15-16	Detection of naturally occurring fungicide resistant mutants of pathogen
6	17-18	Methods of application of chemicals

VII.Suggested Reading

Bindra OS and Singh H. 1977. *Pesticides—And Application Equipment*. Oxford & IBH, New Delhi. Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. 3rd edn. Oxford & IBH, New Delhi. Torgeson DC. (Ed.). 1969. *Fungicides*. Vol. II. An Advanced Treatise. Academic Press, New York. Vyas SC. 1993. *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

I. Course Title: Detection and management of Seed Borne Pathogens**II. Course Code: PI PATH 512****III. Credit Hours: 2+1****IV. Aim of the course**

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/ losses and management.

V. Theory**Unit I**

History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

Unit II

Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

Unit III

Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

Unit IV

Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

VI. Practical

- Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses;
- Relationship between seed-borne infection and expression of the disease in the field.

Teaching Schedule

Theory		
Lecture No.	Topic	Weightages (Percent)
1-8	History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.	20-25
9-18	Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens	30-35
19-22	Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection	30-35
23-32	Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed	20-25

	production. Seed health testing, methods for detecting microorganism	
	Total	100-120

Practical

S. No.	P. no.	Topics
1	1-9	Conventional and advanced techniques in the detection and identification of seed- borne fungi, bacteria and viruses;
2	10-16	Relationship between seed-borne infection and expression of the disease in the field

VII. Suggested Reading

- Agarwal VK and Sinclair JB. 1993. *Principles of seed Pathology*. Vols. I & II, CBS Publ., New Delhi.
- Hutchins JD and Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, Wallington.
- Paul Neergaard. 1988. *Seed Pathology*. McMillan, London.
- Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

I. Course Title: Biological control of Plant Pathogens**II. Course Code: PI PATH 513****III. Credit Hours: 1+1****IV. Aim of the course**

To study principles and application of eco-friendly and sustainable management strategies of plant diseases.

V. Theory**Unit I**

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

Unit II

Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

Unit III

Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic microbes.

Unit IV

Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

VI. Practical

- Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in-vitro* and *in vivo* conditions;
- Preparation of different formulations of selected bioagents and their mass production;
- Quality parameters of biocontrol agents;
- One-week exposure visit to commercial biocontrol agent's production unit.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-5	Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.	20-25
6-10	Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.	30-35
11-16	Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic microbes.	30-35

17-23	Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents	20-25
Total		100-120

Practical

S. No.	P. No.	Topics
1	1-4	Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen <i>in-vitro</i> and <i>in vivo</i> conditions
2	5-8	Preparation of different formulations of selected bioagents and their mass production;
3	9-12	Quality parameters of biocontrol agents
4	12-16	One-week exposure visit to commercial biocontrol agent's production unit

VII. Suggested Reading

Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*. Cambridge Univ. Press, Cambridge.

Cook RJ and Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens*. APS, St. Paul, Minnesota.

Fokkemma MJ. 1986. *Microbiology of the Phyllosphere*. Cambridge Univ. Press, Cambridge.

Gnanamanickam SS (Eds). 2002. *Biological Control of Crop Diseases*. CRC Press, Florida.

Heikki MT and Hokkanen James M. (Eds.). 1996. *Biological Control – Benefits and Risks*. Cambridge Univ. Press, Cambridge.

Mukerji KG, Tewari JP, Arora DK and Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi.

I. Course Title: Integrated Disease Management**II. Course Code: PI PATH 514****III. Credit Hours: 2+1****IV. Aim of the course**

To emphasize the importance and the need of IDM in the management of diseases of important crops.

V. Theory**Unit I**

Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

Unit II

Development of IDM-basic principles, biological, chemical and cultural disease management.

Unit III

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses, vegetable crops, fruit, plantation and spice crops.

VI. Practical

- Application of physical, biological and cultural methods
- Use of chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM and multiple disease management in crops of regional importance as project work.

Teaching Schedule**Theory**

S. No.	Topic	Weightages (Percent)
1- 10	Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications	20-30
11-22	Development of IDM-basic principles, biological, chemical and cultural disease management.	40-45
12-28	IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses, vegetable crops, fruit, plantation and spice crops	40-45
	Total	100-120

Practical

Sr. No.	P. No.	Topics
1	1-9	Application of physical, biological and cultural methods
2	10-15	Use of chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM and multiple disease management in crops of regional importance as project work

VII. Suggested Reading

Gupta VK and Sharma RC. (Eds). 1995. *Integrated Disease Management Arid Plant Health*. Scientific Publ., Jodhpur.

Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS and Deshpande Jayashree (Eds.). 2004. *Biotechnological Approaches for the Integrated Management of Crop Diseases*. Daya Publ. House, New Delhi.

Sharma RC and Sharma JN. (Eds). 1995. *Integrated Plant Disease Management*. Scientific Publ., Jodhpur.

I. Course Title: Diseases of Field and Medicinal crops**II. Course Code: PI PATH 515****III. Credit Hours: 2+1****IV. Theory****Unit I**

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

Unit II

Diseases of Pulse crops- Gram, urdbean, 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 VIMedicinal crops- *Plantago*, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, *Aloe vera*.**V. 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.

Teaching Schedule**Theory**

S. No.	Topic	Weightages (Percent)
1	Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize	20-22
2	Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.	20-22
3	Diseases of Oilseed crops- Rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.	20-22
4	Diseases of Cash crops- Cotton, sugarcane	15-20
5	Diseases of Fodder legume crops- Berseem, oats, guar, lucerne.	15-20
6	Medicinal crops- <i>Plantago</i> , liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, <i>Aloe vera</i> .and health hazards, fungicidal resistance in plant pathogens and its management.	10-14
Total		100-120

Practical

S. No.	P. No.	Topics
1	1-10	Study of symptoms, etiology, host-parasite relationship and control measures of the following crop diseases.
2	11-16	Field survey, collection and preservation of disease samples of rice, sorghum, bajra wheat, maize, sugarcane, turmeric, groundnut, castor, sunflower, safflower, linseed, sesamum, cotton, pigeonpea, chickpea, mung and urid.

VI. Suggested Reading

Joshi LM, 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.

Ricanel 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. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

I. Course Title: Diseases of Fruits, Plantation and Ornamental Crops**II. Course Code: PI PATH 516****III. Credit Hours: 2+1****IV. Aim of the course**

To acquaint with diseases of fruits, plantation, ornamental plants and their management.

V. Theory**Unit I**

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.

Unit II

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.

Unit III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera orchids, marigold, chrysanthemum and their management.

VI. Practical

- Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops;
- Collection and dry preservation of diseased specimens of important crops.

Teaching Schedule**Theory**

S.No.	Topic	Weightages (Percent)
1- 8	Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.	20-30
10-20	Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.	40-45
21-28	Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera orchids, marigold, chrysanthemum and their management.	40-45
	Total	100-120

Practical

Sr. No.	P. No	Topics
1	1-2	Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops
2	3-5	Collection and dry preservation of diseased specimens of important crops

VII. Suggested Reading

- Gupta VK and Sharma SK. 2000. *Diseases of Fruit Crops*. Kalyani Publishers, New Delhi. Pathak VN. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
 Singh RS. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
 Walker JC. 2004. *Diseases of Vegetable Crops*. TTPP, India.

I. Course Title: Diseases of Vegetable and Spices Crops**II. Course Code: PI PATH 517****III. Credit Hours: 2+1****IV. Aim of the course**

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

V. 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.

VI. Practical

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

Teaching Schedule**Theory**

Lecture No	Topic	Weightages (Percent)
1- 10	Nature, prevalence, factors affecting disease development of tuber, bulb, leafy vegetable, crucifers, cucurbits and solanaceous vegetables. Diseases of crops under protected cultivation.	20-30
10-20	Symptoms and management of diseases of different root, tuber, bulb, leafy vegetables, crucifers, cucurbits and solanaceous vegetable crops.	40-45
21-28	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.	40-45
	Total	100-120

Practical

Sr. No.	P. No	Topics to be covered
1	16	Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops. (For each crop one practical period)

VII. Suggested Reading

Chaube HS, Singh US, Mukhopadhyay AN and Kumar J. 1992. *Plant Diseases of International Importance*. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.

Gupta VK and Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publishers, New Delhi

Gupta SK and Thind TS. 2006. *Disease Problem in Vegetable Production*. Scientific Publ., Jodhpur. Sherf AF and Mcnab AA. 1986. *Vegetable Diseases and their Control*. Wiley Inter Science, Columbia.

Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New

Delhi. Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

I. Course Title: Post-Harvest Diseases**II. Course Code: PI PATH 518****III. Credit Hours: 1+1****IV. Aim of the course**

To acquaint with the post-harvest diseases of agricultural produce and their eco- friendly management.

V. Theory**Unit I**

Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problems both by biotic and abiotic factors.

Unit II

Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.

Unit III

Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards.

Unit IV

Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarius for each product and commodity. Physical and biological agents/ practices responsible for development/ prevention of post-harvest diseases- traditional and improved practices.

VI. Practical

- Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens *in vivo* condition;
- Comparative efficacy of different fungicides and bioagents;
- Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers;
- Visit to cold storage.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-3	Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problems both by biotic and abiotic factors.	20-25
4-6	Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.	30-35
7-10	Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of	30-35

	aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards.	
11-18	Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarius for each product and commodity. Physical and biological agents/ practices responsible for development/ prevention of post-harvest diseases-traditional and improved practices	20-25
	Total	100-120

Practical

S. No.	P. No.	Topics
1	1-9	Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens <i>in vivo</i> condition
2	10-13	Comparative efficacy of different fungicides and bioagents
3	14-16	Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers
4	17	Visit to cold storage

VII. Suggested Reading

Chaddha KL and Pareek OP. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.

Pathak VN. 1970. *Diseases of Fruit Crops and their Control*. IBH Publ., New Delhi.

I. Course Title: Plant Quarantine and Regulations**II. Course Code: PI PATH 519****III. Credit Hours: 1+0****IV. Aim of the course**

To acquaint the learners about the principles and the role of plant quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

V. Theory**Unit I**

Historical development in plant quarantine, Definitions of pest, and transgenics as per Govt. notification; Organizational set up of plant quarantine in India. relative importance; quarantine — domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.

Unit II

Acts related to registration of pesticides and transgenics. History of quarantine legislations, Salient features of PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Unit III

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

Unit IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-3	Historical development in plant quarantine, Definitions of pest, and transgenics as per Govt. notification; Organizational set up of plant quarantine in India. relative importance; quarantine -domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.	10-11
4-6	Acts related to registration of pesticides and transgenics. History of quarantine legislations, Salient features of PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.	15-17
7-10	Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.	15-17
11-16	WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.	10-15
Total		50-60

VI. Suggested Reading

Rajeev K and Mukherjee RC. 1996. Role of Plant Quarantine in IPM. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: Hand book of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

Ph.D Course Contents & Course Structure

1. Ph. D. (Ag.) Plant Pathology

Course Code	Term	Course Title	Credit Hrs.
PL PATH601	I	Advances in Mycology	2+1=3
PL PATH602	I	Advances in Virology	2+1=3
PL PATH603	I	Advances in plant Pathogenic Prokaryotes	2+1=3
PL PATH604*	II	Molecular Basis of host Pathogen Interaction	2+1=3
PL PATH605	II	Principles & Procedures of Certification	1+0=1
PL PATH606	II	Plant Biosecurity & Safety	2+0=2
PL PATH691	III	Doctoral Seminar-I	0+1=1
PL PATH692	IV	Doctoral Seminar-II	0+1=1
		Total	11+6=17
	V	Doctoral Research	
	VI	Doctoral Research	
PL PATH699	III	Doctoral Research	0+75

**Compulsory Courses

Optional Courses :

Course Code	Semester	Course Title	Credit Hrs.
STAT 502		Statistical Methods for Applied Sciences	2+1
STAT 602		Experimental Designs	2+1
STAT 521		Applied Regression Analysis	2+1
BIOCHEM 501		Basic Biochemistry	3+1
BIOCHEM 505		Techniques in Biochemistry	2+2
MCA 512		Information Technology in Agriculture	1+1

Minor Disciplines:

11. Agronomy
12. Agril Entomology
13. Agril. Botany
14. Biotechnology
15. Horticulture

16. Plant Physiology
17. Microbiology
18. Agril. Chemistry and Soil Science
19. Agril. Extention
20. Agril Economics

Semester Layout:**Ph.D. Agriculture (Plant Pathology)**

Semester	Course Code	Course Title	Credit Hrs.
I	PL PATH601	Advances in Mycology	2+1=3
	PL PATH602	Advances in Virology	2+1=3
	PL PATH603	Advances in plant Pathogenic Prokaryotes	2+1=3
II	PL PATH604*	Molecular Basis of host Pathogen Interaction	2+1=3
	PL PATH605	Principles & Procedures of Certification	1+0=1
	PL PATH606	Plant Biosecurity & Safety	2+0=2
III	PL PATH691	Doctoral Seminar-I	0+1=1
	PL PATH699	Doctoral Research	0+75=75
IV	PL PATH692	Doctoral Seminar-II	0+1=1
		Total	11+6 =17
V		Doctoral Research	
VI		Doctoral Research	
		Doctoral Research	0+75=75

Credit Requirements

	Course Work	Doctoral Programme
(I)	Major Courses	17
	Minor Courses	06
	Supporting Courses	05
	Common Courses	-
	Seminar	02
(II)	Thesis Research	75
	Total	105

(Recent Advances should be included in all courses time to time)

Course Contents
Ph.D. in Plant Pathology

I. Course Title: Advances in Mycology

II. Course Code: PI PATH 601

III. Credit Hours: 2+1

IV. Aim of the course

To acquaint with the advances in mycology

V. Theory

Unit I

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer-based assessment) taxonomy. Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.

Unit II

Population biology, pathogenic variability/vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra -nuclear inheritance. Biodegradation.

Unit III

Ultra-structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and eommensalism.

Unit IV

Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles — characterization process and application. Mycotoxins problems and its management.

VI. Practical

- Isolation, purification and identification of cultures, spores and mating type determination;
- Study of conidiogenesis-Phialides, porospores, arthrospores;
- Study of fruiting bodies in Aseomycotina;
- Identification of fungi up to species level;
- Study of hyphal anastomosis;
- Morphology of representative plant pathogenic genera form different groups of fungi;
- Molecular characterization of fungi.

Teaching Schedule

Theory

Lecture No.	Topic	Weightages (Percent)
1-8	General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer-based assessment) taxonomy. Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfectii.	20-25
9-18	Population biology, pathogenic variability/vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra -nuclear inheritance. Biodegradation.	30-35
19-22	Ultra-structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis,	30-35

	meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.	
23-32	Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles — characterization process and application. Mycotoxins problems and its management	20-25
	Total	100-120

Practical

S. No.	P. No.	Topics
1	1-3	Isolation, purification and identification of cultures, spores and mating type determination;
2	4-6	Study of conidiogenesis-Phialides, Porospores, Arthrospores
3	7-9	Study of fruiting bodies in Ascomycotina
4	10-12	Identification of fungi up to species level
5	13-14	Study of hyphal anastomosis
6	15-16	Morphology of representative plant pathogenic genera from different groups of fungi
7	17-18	Molecular characterization of fungi.

VII. Suggested Reading

Alexopoulos C J, Mims C W and Blackwell M. 1996. *Introductory Mycology*. John Wiley & Sons, New York.

Dube HC. 2005. *An Introduction to Fungi*. 3rd Ed. Vikas Publ. House, New Delhi.

Kirk PM, Cannon PF, David JC and Stalpers JA. (Eds.). 2001. *Ainsworth and Bisby's Dictionary of Fungi*. 9th Ed., CABI, Wallington.

Maheshwari R. 2016. *Fungi. - Experimental Methods in Biology* 2nd edn. CRC Press, US. Ulloa M and Hanlin RT. 2000. *Illustrated Dictionary of Mycology*. APS, St. Paul, Minnesota.

Webster I and Weber R. 2007. *Introduction of Fungi*. Cambridge University Press, Cambridge.

I. Course Title: Advances in Plant Virology**II. Course Code: PI PATH 602****III. Credit Hours: 2+1****IV. Aim of the course**

To educate about the advanced techniques and new developments in plant virology.

V. Theory**Unit I**

Origin, evolution and interrelationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/ strains: mutation, recombination, pseudo- recombination, component re-assortment, etc.

Unit II

Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses. Immuno/serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid-based assays for detection of plant viruses.

Unit III

Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non-PCR based: LAMP, Fluorescent in site hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome- information content, coding and non- coding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.

Unit IV

Gene expression, regulation and viral promoters. Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

VI. Practical

- Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation;
- Acquaintance with different serological techniques (i) DAC- ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation, and autoradiography;
- PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny);
- Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs)

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-8	Origin, evolution and interrelationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/ strains: mutation, recombination, pseudo-recombination, component re-assortment, etc.	20-25

9-18	Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses. Immuno / serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid-based assays for detection of plant viruses.	30-35
19-22	Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non-PCR based: LAMP, Fluorescent in site hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome-information content, coding and non-coding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA	30-35
23-32	Gene expression, regulation and viral promoters. Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.	20-25
Total		100-120

Practical

S. No.	P. No	Topics
1	1-4	Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation
2	5-7	Acquaintance with different serological techniques (i) DAC- ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation, and autoradiography
3	8-12	PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny
4	13-15	Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs).

VII. Suggested Reading

- Davies 1997. *Molecular Plant Virology: Replication and Gene Expression*. CRC Press, Florida. Fauquet *et al.* 2005. *Virus Taxonomy*. VIII Report of ICTV. Academic Press, New York.
- Gibbs A and Harrison B. 1976. *Plant Virology - The Principles*. Edward Arnold, London.
- Jones P, Jones PG and Sutton JM. 1997. *Plant Molecular Biology. - Essential Techniques*. John Wiley & Sons, New York.
- Khan J A and Dijkstra. 2002. *Plant Viruses as Molecular Pathogens*. Howarth Press, New York.

- Maramorosch K, Murphy FA and Shatkin AJ. 1996. *Advances in Virus Research*. Vol. 46. Academic Press, New York.
- Pirone TP and Shaw JG. 1990. *Viral Genes and Plant Pathogenesis*. Springer Verlag, New York.
- Roger Hull. 2002. *Matheuw's Plant Virology* (4th Ed.). Academic Press, New York.
- Thresh JM. 2006. *Advances in Virus Research*. Academic Press, New York.

I. Course Title: Advances in Plant Pathogenic Prokaryotes**II. Course Code: PI PATH 603****III. Credit Hours: 2+1****IV. Aim of the course**

To learn about the latest developments in all the plant pathogenic prokaryotes as a whole.

Theory**Unit I**

Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition (bacteria) cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof Pathway (EMP) pathway, Phosphoketolase Pathway and Entner Doudoroff Pathway).

Unit II

Current trends in taxonomy and identification of phytopathogenic prokaryote: International code of nomenclature, Polyphasic approach, New/ special detection methods for identification of bacterial plant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.

Unit III

Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.

Unit IV

Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, etc. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.

Unit V

Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

VI. Practical

- Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteria using species/ pathovar specific primers;
- Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts;
- Important and emerging diseases and their management strategies.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-6	Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition (bacteria) cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof	20-24

	Parmas (EMP) pathway, Phosphoketolase Pathway and Entner Doudoroff Pathway).	
7-12	Current trends in taxonomy and identification of phytopathogenic prokaryote: International code of nomenclature, Polyphasic approach, New/ special detection methods for identification of bacterial plant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.	20-24
13-18	Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome	24-28
19-22	Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, etc. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.	18-22
23-27	Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9	18-22
	Total	100-120

Practical

Sr. No	P. No.	Topic
1	1-10	Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteria using species/ pathovar specific primers
2	11-14	Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts
3	15-16	Important and emerging diseases and their management strategies

VII. Suggested Reading

- Dale MW and Simon P. 2004. *Molecular Genetics of Bacteria*. John Wiley & Sons, New York. Garrity GM, Krieg NR and Brenner DJ. 2006. *Bergey's Manual of Systematic Bacteriology: The Proteobacteria*. Vol. II. Springer Verlag, New York.
- Gnanamanickam SS. 2006. *Plant-Associated Bacteria*. Springer Verlag, New York.
- Mount MS and Lacy GH. 1982. *Plant Pathogenic Prokaryotes*. Vols. I, II. Academic Press, New York.
- Sigeo DC. 1993. *Bacterial Plant Pathology: Cell and Molecular Aspects*. Cambridge Univ. Press, Cambridge.
- Starr MP. 1992. *The Prokaryotes*. Vols. I—IV. Springer Verlag, New York.
- B. S. Thind 2012. *Phytopathogenic Prokaryotes and Plant diseases*, scientific publishers India

I. Course Title: Molecular Basis of Host- Pathogen Interaction**II. Course Code: PI PATH 604****III. Credit Hours: 2+1****IV. Aim of the course**

To understand the concepts of molecular biology and biotechnology in relation to host plant-pathogen interactions.

v. Theory**Unit I**

History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles to study host pathogen relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.

Unit II

Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions. Plant innate immunity: PAMP/ DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

Unit III

Induction of defence responses- HR, programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes. Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.

Unit IV

Pathogen population genetics and durability, virus's vs cellular pathogens. Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

VI. Practical

- Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation;
- Gene mapping and marker assisted selection;
- Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-8	History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles to study host pathogen relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.	20-25
9-18	Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions. Plant innate immunity: PAMP/ DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction	30-35

19-22	Induction of defence responses- HR, programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes. Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.	30-35
23-32	Pathogen population genetics and durability, virus's vs cellular pathogens. Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.	20-25
Total		100-120

Practical

S. No.	P. No	Topics
1	1-10	Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation
2	11-15	Gene mapping and marker assisted selection
3	16-17	Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management

VII. Suggested Reading

- Chet I. 1993. *Biotechnology in Plant Disease Control*. John Wiley & Sons, New York.
- Gurr SJ, McPohersen MJ and Bowlos DJ. (Eds.). 1992. *Molecular Plant Pathology – A Practical Approach*. Vols. I & II, Oxford Univ. Press, Oxford.
- Mathew JD. 2003. *Molecular Plant Pathology*. Bios Scientific Publ., UK.
- Ronald PC. 2007. *Plant-Pathogen Interactions: Methods in Molecular Biology*. Humana Press, New Jersey.
- Stacey G and Keen TN. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

I. Course Title: Principles and Produces of Certification**II. Course Code: PI PATH 605****III. Credit Hours: 1+0****IV. Aim of the course**

To acquaint with the certification procedures of seed and planting material.

V. Theory**Unit I**

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD, etc. in certification and quality control. Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health, etc. Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.

Unit II

Methods used in certification of seeds, vegetative propagules and *in-vitro* cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

Teaching Schedule**Theory**

Lecture No.	Topic	Weightages (Percent)
1-8	Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD, etc. in certification and quality control. Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health, etc. Fixing tolerance limits for diseases and insect pests in certification and quality control programmes	25-30
9-18	Methods used in certification of seeds, vegetative propagules and <i>in-vitro</i> cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.	25-30
Total		50-60

VI. Reference

- Association of Official Seed Certifying Agencies. Hutchins D and Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, UK. ISHI-veg Manual of Seed Health Testing Methods.
- ISHI-F Manual of Seed Health Testing Methods.
- ISTA Seed Health Testing Methods.
- Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi. US National Seed Health System.

e-Resources

<http://www.aosca.org/index.htm>.

http://www.worldseed.org/enus/international1_seed/ishi_vegetable.html

http://www.worldseed.org/en-us/international_seed/ishi_f.html

<http://www.seedtest.org/en/content—1-1132-241.html>

<http://www.seedhealth.org>

I. Course Title: Plant Biosecurity and Biosafety**II. Course Code: PI PATH 606****III. Credit Hours: 2+0****IV. Aim of the course**

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

V. Theory**Unit I**

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases. Introduction and History of biosecurity and its importance.

Unit II

National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures. World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Unit III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops. Emerging/ resurgence of pests and diseases in the changing scenario of climatic conditions. Issues related to release of genetically modified crops.

Teaching Schedule**Theory**

S. No.	Topic	Weightages (Percent)
1- 7	History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases. Introduction and History of biosecurity and its importance	20-30
8-10	National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures. World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.	40-45
11-14	Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops. Emerging/ resurgence of pests and diseases in the changing scenario of climatic conditions. Issues related to release of genetically modified crops	40-45
	Total	100-120

VI. Suggested Reading

- Biosecurity: A Comprehensive Action Plan.
 Biosecurity Australia.
 Biosecurity for Agriculture and Food Production.
 FAO Biosecurity Toolkit 2008.
 Grotto Andrew J and Jonathan B Tucker. 2006. Biosecurity Guidance.
 Khetarpal RK and Kavita Gupta 2006. Plant Biosecurity in India — Status and Strategy.
 Asian Biotechnology and Development Review 9(2): 3963.
 Randhawa GJ, Khetarpal RK, Tyagi RK and Dhillon BS (Eds.). 2001. Transgenic Crops and
 Biosafety Concerns. NBPGR, New Delhi.

e-Resources

- <http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.shtm>
www.fao.org/docrep/010/all40e/a1140e00.htm Laboratory
http://www.who.int/csr/resources/publications/biosafety/WHO_CD_S_EPR_2006.pdf
http://www.americanprogress.org/kf/biosecurity_a_comprehensive_action_plan.pdf
www.biosecurity.govt.nz DEFRA.
www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
www.daff.gov.au/ba; www.affa.gov.au/biosecurityaustralia Biosecurity New Zealand.
<http://www.fao.org/biosecurity/> CPIA.

VII. List of Journals

- *Annals of Applied Biology*— Cambridge University Press, London
- *Annals of Plant Protection! Sciences* - Society of Plant Protection, IARI, New Delhi
- *Annual Review of Phytopathology* — Annual Reviews, Palo Alto, California
- *Annual Review of Plant Pathology* — Scientific Publishers, Jodhpur
- *Canadian Journal of Plant Pathology* — Canadian Phytopathological Society, Ottawa
- *Indian Journal of Biotechnology* — National Institute of Science Communication and Information Resources, CSIR, New Delhi
- *Indian Journal of Mycopathological Research* — Indian Society of Mycology, Kolkata.
- *Indian Journal of Plant Protection* — Plant Protection Association of India, NBPGR, Hyderabad.
- *Indian Journal of Virology* — Indian Virological Society, New Delhi
- *Indian Phytopathology*-Indian Phytopathological Society, IARI New Delhi.
- *Journal of Mycology and Plant Pathology* — Society of Mycology and Plant Pathology, Udaipur.
- *Journal of Plant Disease Science*- Association of Plant Pathologists (Central India) PDKV, Akola.
- *Journal of Phytopathology* — Blackwell Verlag, Berlin
- *Mycologia* — New York Botanical Garden, Pennsylvania
- *Mycological Research* — Cambridge University Press, London
- *Physiological Molecular Plant Pathology* — Academic Press, London
- *Phytopathology* — American Phytopathological Society, USA
- *Plant Disease* — The American Phytopathological Society, USA
- *Plant Disease Research* — Indian Society of Plant Pathologists, Ludhiana
- *Plant Pathology* — British Society for Plant Pathology, Blackwell Publ.
- *Review of Plant Pathology* — CAB International, Wallingford
- *Virology*- New York Academic Press e-Resources
- www.shopapspress.org
- www.apsjournals.apsnet.org
- www.apsnet.org/journals
- www.cabi_publishing.org
- www.springer.com/life+Sci/agriculture
- www.backwellpublishing.com
- www.csiro.au
- www.annual-reviews.org

REVISED BSMA SYLLABUS

For

M.Sc. (Agri.)

Ph. D. (Agri.)

in

Sericulture

Broad Subject Coordinator

Plant Protection and

HOD Agril. Entomology, MPKV,

Rahuri.

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Preamble:**Salient feature of revised syllabi and major changes made including new courses/topics added**

- ✓ M.Sc. (Agri.) in sericulture courses for majority of the courses the title has been modified and syllabi is upgraded based on the recent advances in that particular course/ field .
- ✓ In the Genetics and Breeding of Mulberry course the recent technologies such as nano technology is included.
- ✓ The pests and diseases of both silkworms and host plant have been split into two courses separately for silkworms and mulberry.
- ✓ The silkworm seed and cocoon production the course have also separated into two courses viz., silkworm egg production technology and silkworm rearing technology including the seed act 2010 by increasing one more credit hour.
- ✓ In the course silk technology it has been split into two courses i.e, Silk Technology-I for (M.Sc.) and silk technology-II for (Ph.D) which covers the advanced technologies.
- ✓ In the course Non-mulberry sericulture the contents and syllabus is upgraded with more practical orientation including proteomics, transcriptomics and genomics organism.
- ✓ In the minor courses viz., nutrition of host plant of silkworms recent topics on fertilizer use efficiency, enumeration of soil micro flora, trenching and mulching techniques in mulberry have been included.
- ✓ The biotechnological aspects of silkworms a mulberry dealt separately with more emphasis on practical aspects.
- ✓ In the sericulture by product utilization and value addition more emphasis has been laid on recycling of flimsy/ waste cocoons, use of seri proteins etc.

Ph.D (Agri.) in Sericulture:

- ✓ The course title and syllabi of most of the courses modified keeping the recent advances in the courses in mind.
- ✓ The conventional, non-conventional methods of breeding, evaluation of germplasm for different stresses and _recent breeding techniques applicable to mulberry have been included.
- ✓ The new topics an aeroponics and hydroponics are included.
- ✓ In the integrated pest management in sericulture course, the new topics such as taxonomy of protozoan and fungal species and different dis-infectetants used have also been covered.
- ✓ In the minor courses the silk technology-II is added to deal with new topics such as species and type concepts and recent preservation techniques.
- ✓ In the seri business management course the credit hours increased with more practical components and visit to seri business units / centre / institution/ NGO's, tasar & muga reeling technology, silk testing and grading, SERM and ARM, non-mulberry silk reeling technology etc.,

Aspects included in line with the national initiatives:

- Detailed study of silkworm and mulberry pests and diseases
- Seed act 2010
- Advanced silk technological aspects
- Fertilizer use efficiency.
- Trenching and mulching technique in mulberry
- Seri by product utilization, value addition
- Poly cross breeding in mulberry
- Histopathology of viruses, protozoans
- Entrepreneurship development in sericulture
- Silk preservation techniques
- Non mulberry silk reeling technology.

Topics covered related to global development:

- Nano technology
- Soil microflora
- Hydroponic and aeroponics
- Genomics, proteomics and transcriptomics

- Seri protein usage

The following nomenclature and Credit Hrs has been followed while providing the syllabus.

	Masters' Programme	Doctoral Programme
i. Course work		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	-
Seminar	01	02
ii. Thesis Research	30	75
Total	70	100

Committee for Revision of PG Syllabus in Sericulture

Sr. No	Name of the member	Designation	Co- opted members from four Agricultural Universities of Maharashtra
1	Dr. C.S. Patil	Head, Department of Entomology, MPKV, Rahuri.	Chairman
2	Dr. D.B. Undirwade	Head, Department of Entomology, PDKV, Akola.	Member
3	Dr. S.D. Bantewad	Head, Department of Entomology, VNMKV, Parbhani.	Member
4	Dr. P.R. Zanwar	Associate professor of Entomology and Principal, Agriculture Technical School, VNMKV, Parbhani.	Member
5	Dr.M.M. Karmarkar	Associate professor, Department of Entomology, Dr.BSKKV, Dapoli.	Member
6	Dr. C.B. Latpate	Associate professor & Officer In-Charge Sericulture Research Unit.	Secretary

Course contents for M. Sc. (Agri.) in Sericulture

COURSES FOR M. Sc (Agri.) IN SERICULTURE

Course No.	COURSE TITLE	CREDITS
Major courses		
SER 501	Mulberry Production Technology	1+1
SER 502	Genetics and Breeding of Mulberry	1+1
SER 506	Systematics and Morphology of Sericigenous insects	1+1
SER 509	Silkworm Egg Production Technology	1+1
SER 510	Silkworm Rearing Technology	1+1
SER 511	Genetics and Breeding of Silkworms	1+1
SER 512	Diseases and Pests of Silkworms	1+1
SER 514	Silk Technology-I	1+1
SER 515	Non-mulberry Sericulture	1+1
		09+09=26
Minor courses		
*		
SER 503	Nutrition of Host Plants of Silkworms	1+1
SER 504	Mulberry Pests and Diseases	2+1
SER 505	Biotechnology of Mulberry	1+1
SER 507	Anatomy and Physiology of Sericigenous insects	1+1
SER 508	Silkworm Biochemistry and Nutrition	1+1
SER 513	Biotechnology of Silkworm	1+1
SER 516	Sericulture By-product utilization and Value addition	1+1
		8+7=15
Supporting courses		
1	Agronomy	1+1
2	Horticulture	0+1
3	Techniques in Plant Protection	0+1
4	Insect vectors of Plant Pathogen	1+0
5	Plant quarantine, Bio safety and Bio security	1+0
6	Organic Sericulture farming	0+1
		3+4 =07

***Note: The students may opt the optional courses from any disciplines / departments as recommended by the advisory committee of the student based on the research topic.**

Course Code: SER 501

Course Title: Mulberry Production Technology

WHY THIS COURSE?

Mulberry is a perennial deep-rooted high biomass producing foliage crop, cultivated as a sole food for silkworm (*Bombyx mori* L). Mulberry cultivation is the very foundation of commercial sericulture to raise a successful cocoon crop. The quantity of leaf produced and its quality has a direct bearing on silkworm health and the quantity of cocoons produced. Thus, the profitability of sericulture and quality of cocoons depends on nutritive quality of mulberry leaves, as nearly as 70% of the silk proteins produced by the silkworm are directly derived from the mulberry leaves in addition to other nutrients. Hence, cultivation and best yield of the mulberry plants occupy important place in sericulture.

AIM OF THIS COURSE

The course is designed to provide both theory and practical knowledge on scope of mulberry sericulture, global distribution and factors influencing mulberry leaf yield and quality. Mulberry varieties, selection of site for garden, propagation techniques, soil and climatic requirements will be taught. Package of practices for raising mulberry saplings, rainfed and irrigated mulberry cultivation, separate chawki garden, tree mulberry, mulberry cultivation in hilly areas, intercropping, organic farming and IFS component will be part of the course. Use of growth hormones and growth regulators on mulberry leaf yield and quality will be studied in addition to pests and diseases of mulberry. Mulberry farm management and economics of mulberry production will be added.

The course is organized as follows:

No	Blocks	Units
1	Introduction, scope and varieties	1. Overview and Scope of mulberry sericulture
		2. Varieties of mulberry
2	Mulberry production	1. Raising of mulberry saplings and planting.
		2. Establishment of mulberry garden
3	Mulberry Protection	1. Mulberry pests and their management
		2. Mulberry diseases and their management
4	Economics	1. Economic of mulberry production

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Appreciate the scientific foundation of mulberry cultivation and relate the key learning to both research and extension
- Utilise methods and tools for mulberry nursery and mulberry production
- Utilise material in scientific publications relevant to mulberry production technology and adoption that critically reflect on their benefits.

Block 1: Introduction, scope and varieties

Unit 1: Overview and Scope of mulberry sericulture

Scope of mulberry sericulture, an overview of sericulture industry in the world and India. Leaf quality requirements, factors influencing mulberry leaf yield and quality. Scope for mechanization in mulberry cultivation.

Unit 2: Varieties of mulberry

Mulberry varieties, Traditional mulberry varieties, popular mulberry varieties in different climatic zones, high yielding varieties, varieties for rainfed condition, varieties for specific conditions.

Block 2: Mulberry production

Unit 1: Raising of mulberry saplings and planting.

Technology for raising of saplings for bush and tree type mulberry cultivation. Preparation of bed, planting material, transportation, storage, planting, weeding, fertilizer application and disease and pest management, uprooting, transportation and planting in main field.

Unit 2: Establishment of mulberry garden

Package of practices for rainfed and irrigated mulberry cultivation, separate chawki garden, tree mulberry, mulberry cultivation in hilly areas. Selection of land, land preparation, planting, initial care and maintenance for different methods of mulberry cultivation and pruning practices. Mechanization in mulberry cultivation, intercropping, organic farming and IFS component. Manure and fertilizer schedule, irrigation schedule, use of bio fertilizers for enhanced yield, use of growth hormones and growth regulators.

Block 3: Mulberry protection

Unit -1 Mulberry pests and their management

Mulberry pest status, occurrence, type of damage, symptoms, crop loss, life-cycle, different methods of management techniques, Integrated Pest Management (IPM) in mulberry.

Unit-2 Mulberry diseases and their management

Mulberry diseases, occurrence, damage, symptoms, crop loss & different methods of management techniques and Integrated Disease Management (IDM) in mulberry.

Block 4: Economics

Unit -1: Economic of mulberry production

Farm records, role of non-monetary inputs in mulberry production, effective farm management, economics of mulberry production.

PRACTICALS

1. Analysis of area, production and productivity of mulberry and sericulture in Karnataka, India and world.
2. Study of Agronomic features of different mulberry varieties.
3. Practicing of different mulberry planting systems.
4. Study of rooting and sprouting behaviour of mulberry varieties.
5. Raising saplings through soft, semi soft and apical tender shoots.
6. Mulberry nursery establishment and management
7. Study of mulberry as an intercrop in plantations.
8. Selection of fruits and preparation of mulberry seeds for raising mulberry seedlings.
9. Study of different planting systems of tree mulberry.
10. Study of Intercropping in mulberry garden.
11. Study of organic mulberry farming.
12. Study of Mulberry as IFS component.
13. Effect of different pruning systems on mulberry yield.
14. Estimation of leaf area by non-destructive and destructive methods.
15. Study of different leaf preservation techniques and different methods of leaf harvest with special reference to chawki and grown up silkworms.
16. Study of different schedules of operation in mulberry garden and fertilizer application, methods of application and irrigation schedules.
17. Study of weed flora in mulberry garden.
18. Study of Farm records and Economics of mulberry cultivation.
19. Institutional/Farmers field visits

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work

- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

- ANONYMOUS, 1975, *Textbook of Tropical Sericulture*. Japan Overseas Co-operation volunteers, Japan, p.594.
- ARUGA, H., 1994, *Principles of Sericulture*. Oxford & IBH, New Delhi, P.376.
- DANDIN, S.B., JAISWAL AND GIRIDHAR, 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore, p.287.
- GANGA, G. AND SULOCHANA CHETTY, J., 1991, *An Introduction to Sericulture*. Oxford & IBH, New Delhi, p.176.
- GANGA, G., 2003, *Comprehensive Sericulture*. Volume 2. *Silkworm Rearing and Silk Reeling*. Oxford & IBH, New Delhi, p.429.
- GOVINDAIAH, GUPTA, V. P., SHARMA, D. D., RAJADURAI, S. AND NISHITHA NAIK, V., 2005, *Textbook on Mulberry Crop Protection*, p 247.
- JOLLY, M.S., 1987, *Appropriate Sericulture Techniques*. Central Sericultural Research and Training Institute, CSB, Mysore, P.215.
- KAMAL JAISWAL, SUNIL P TRIVEDI, PANDEY, B. N. AND KHATRI, R. K., 2009, *Moriculture*, pp. 130-147.
- KICHISABURO MINAMIZAWA., 1984, *Moriculture: Science of Mulberry Cultivation*, pp. 372-402.
- RANGASWAMY, G., NARASIMHANNA, M.N., KASIVISWANATHAN, K., SASTRY, C.R. AND JOLLY, M.S., 1976, *Manual on Sericulture-I. Mulberry Cultivation*, FAO, Rome, P.150.
- SAVITHRI, G., SUJATHAMMA, P. AND NEERAJA, P., 2016, *sericulture industry: an overview*, pp. 28-35.
- ULLAL, S.R AND NARASIMHANNA, M.N., 1981, *Handbook of Practical Sericulture*, CSB, P.209.

JOURNALS

- *Bulletin Of Indian Academy Of Sericulture*, CSTRI, Berhampore
- *Indian silk*, CSB, Bangalore
- *Journal of Sericultural Science of Japan*, Japan
- *Seridoc*, CSRTI (CSB), Mysore
- *Sericologia*, ISC, Bangalore

- *Korean Journal of Sericulture*, Korea
- *Indian Journal of Sericulture*, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Course code: SER 502

Course Title: Genetics and Breeding of Mulberry

WHY THIS COURSE:

Mulberry is perennial and highly heterozygous crop. In order to develop high yielding mulberry varieties for different situations, genetic principles and different breeding methods are prerequisite. In order to improve mulberry genetically, knowledge on different aspects of origin and diversity, floral structure, biology and pollination, genetic basis and concept of breeding, use of germplasm and conventional methods and non-conventional methods of breeding is essential. Hence this customised course.

AIM OF THIS COURSE:

The course is designed to provide both basic and applied knowledge on the subjects of mulberry origin and diversity, floral structure, biology and pollination, genetic basis and general concept of breeding. Establishment of germplasm and genetic improvement of mulberry by conventional and non-conventional methods of breeding are dealt.

The course is organised as follows:

No.	Blocks	Units
1	Taxonomy and botanical description and classification of mulberry	1. Origin and diversity studies of mulberry
		2. Study of floral structure, biology and pollination
		3. Genetic basis and general concept of mulberry breeding
2	Mulberry germplasm and	1. Mulberry germplasm

	breeding methods	2. Conventional methods of breeding
		3. Non-conventional methods of breeding

LEARNING OUTCOMES:

After successful completion of this course the students are expected to be able to get equipped with the different breeding methods for improvement of mulberry.

Block 1: Taxonomy and botanical description and classification of mulberry

Unit 1:Origin and diversity studies of mulberry

Centre of origin and diversity studies of mulberry, Mulberry species and their distribution in India and other countries. Taxonomy of the genus *Morus*. Botanical description of the *Morus* spp.

Unit 2: Study of floral structure, biology and pollination

Reproduction and genetic constitutions in mulberry –asexual reproduction- characteristics of mulberry florets- sexual behaviour- anthesis-reproductive variability. Pollination in mulberry. Cytology of mulberry, cell division- mitosis and meiosis and their significance. Karyomorphological studies. Microsporogenesis and Megasporogenesis in mulberry. Embryological studies of mulberry.

Unit 3: Genetic basis and general concept of mulberry breeding

Expression of gene: Segregation of genes, linkage, homozygosis, quantitative inheritance, features of polygenic inheritance, population structure, Selection of Parents for Hybridization. Procedure of Hybridization: Pruning and Synchronization of Flowering, Bagging, Tagging, Pollination. Harvesting and storing of F1 seeds, Raising F1 generation. Seedling Selection criteria. Difficulties in hybridization, Consequences of hybridization. Combining ability: general combining ability and specific combining ability, Heritability, genetic advance and genetic divergence.

Block 2: Mulberry germplasm and breeding methods

Unit 1:Mulberry germplasm

Establishment of mulberry, objectives and need, exploration, collection and introduction of mulberry germplasm, acclimatization and utilization. Introductions, world collection of mulberry germplasm, plant quarantine, conservation and maintenance of mulberry germplasm, characterization and evaluation of mulberry germplasm, role of mulberry germplasm study in mulberry improvement.

Unit 2: Conventional methods of breeding

Objectives and pre-requisites of mulberry breeding. Genetics of important traits. Early works of mulberry breeding, problems associated with mulberry breeding, conditions favouring mulberry breeding. Reproductive systems and plant breeding methods, Pollination in mulberry and crossing techniques. Mulberry varieties developed through direct selection, selection without controlled pollination, controlled pollination methods, handling of segregating progenies, Conventional methods of breeding- introduction, clonal selection, backcross method. Intervarietal and distant hybridization. Heterosis breeding. Population improvement. Polycross hybrids – Principles involved, advantages and disadvantages, steps in development of polycross hybrids. Multilocational trial and mulberry authorization programme, testing of feed quality. Advanced generation breeding. Improved varietal evaluation distribution and maintenance. Challenges for future.

Unit 3: Non-conventional methods of breeding

Polyploidy breeding in mulberry: Introduction, origin of polyploids, general features of polyploidy, induction of polyploidy and optimal level, special features of triploids, process of triploid mulberry development, varieties developed by polyploidy breeding in mulberry.

Mutation breeding in mulberry: Induction of mutation, bud mutation and chimeras, mutation breeding achievements in mulberry, usefulness of induced mutation, cutting back treatment, limitations and achievements of mutation breeding in mulberry. Breeding for leaf quality, resistance against diseases and pests, tolerance for drought, alkalinity and salinity. Evaluation of mulberry genotypes for different growth and yield parameters. Centres involved in mulberry improvement. Statistical approaches for yield test: Field plot techniques in mulberry breeding experiments. Different experimental designs-RCBD, ARCBD and LSD. Recent approaches in mulberry improvement: *In vitro* techniques- achievements and prospects.

PRACTICALS

1. Floral structure of mulberry
2. Floral biology of mulberry
3. Practising of staggered pruning in mulberry for inducing flowering
4. Sporogenesis: Micro and Megasporogenesis in mulberry
5. Preparation of mitosis slides in mulberry
6. Preparation of meiosis slides in mulberry
7. Study of pollen morphology, pollen fertility and viability
8. Study of stigma receptivity
9. Pollination and crossing techniques in mulberry
10. Characterization of available mulberry germplasm
11. Collection of mulberry fruits, extraction of seeds and raising of seedlings

12. Practising of selection in segregating population/progenies
13. Study of varietal characteristics of released mulberry varieties
14. Layout of field experiments in mulberry for yield evaluation
15. Techniques of induction of mutants and polyploidy in mulberry
16. Testing for resistance to biotic and abiotic stresses in mulberry
17. Breeding for quality improvement in mulberry
18. Visit to Germplasm research station, CSGRC, Hosur

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading / Writing)
- Text book / Publication reviews
- Student presentations
- Group work
- Students interview of key policy makers
- Case analysis and case studies, guest lectures
- Review of policy documents

RESOURCES

- AMITABH SARKAR, *Mulberry breeding*. Kalyani publication, New Delhi.
- SINGH, B.D., *Plant breeding Principles and methods*. Kalyani publication, New Delhi
- CHAKRABORTI, S.P., ROY CHOWDHURI, S. AND BINDROO, B. B., 2013, *A text book on mulberry breeding and genetics*. Kalyani publications, New Delhi.
- DANDIN, S. B., 1986, Mulberry breeding for tropics. In “*Lectures on Sericulture*” Edt. (G. Boraiah), Suriamya Publishers, Bangalore, pp. 25-28.
- DAS, B. C. AND KRISHNASWAMI, S., 1969, Estimation of components of variation of leaf yield and its traits in mulberry. *Indian J. Seric.*, **9**(1): 26-30.
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- DAS, B. C., AND KATAGIRI, K., 1968, Germination and storage of pollen on its viability. *Indian J. Seric.*, **10**(1) : 37-41.
- GIRIDHAR, K., 1996, Studies on some improved varieties of mulberry and their influence on the silkworm, *Bombyx mori* L. Ph. D. Thesis, Mysore University, Mysore, India.
- JALAJA, K. S. AND RAM RAO, D. M., 2008, Characterization of seven mulberry genotypes for their leaf quality and bioassay with silkworm, *Bombyx mori* L. *Sericologia*, **48**(1):85-93.
- MACHII, H., KOYAMA, A., YAMANUCHI, H. AND KATAGIRI, K., 1997, *Manual for the characterization and evaluation of genetic resources*. Misc. Natl. Inst. Seric. Entomol. Sci., 22:105-124.

- MACHII, M., 1990, Leaf disc transformation of mulberry plant (*Morus alba* L.) by *Agrobacterium Ti plasmid*. *J. Seric. Sci. Japan*, **59**: 105-110.
- MASILAMANI, S., REDDY, A. R., SARKAR, A., SREENIVAS, B. T. AND KAMBLE, C. K., 2000, Heritability and genetic advance of quantitative traits in mulberry (*Morus* spp.). *Indian J. Seric.*, **13**(1): 16-20.
- MOGILI, T., SARKAR, A. REDDY AND MUNIRATHNAM, 2002, Effect of salinity stress on some improved varieties of mulberry, *Morus spp. Sericologia*, **42**(2): 149-163.
- OKA, S. AND TEWARY, P. K., 2000, Induction of hairy roots from hypocotyls of mulberry (*Morus indica* L.) by Japanese wild strains of *Agrobacterium rhizogenes*. *J. Seric. Sci. Japan*, **69**: 13-19.
- RANGASWAMI, G., NARASIMHANNA, M. N., KASIVISWANATHAN, K., SASTRY, C. R. AND JOLLY, M. S., 1978, Manual of Sericulture. Vol. 1 Mulberry Cultivation, FAO, Rome, p.150.
- SARKAR, A. AND FUJITA, H., 1993b, Japanese system of mulberry breeding: First selection. *Indian Silk*, September, 9-14.
- SARKAR, A., JALAJA KUMAR, S. AND DATTA, R. K., 2000, Gradual improvement of mulberry varieties under irrigated condition in South India and the optimal programme for varietal selection in the tropics. *Sericologia*, **12**: 142-148.
- SASTRY, C. R., 1984, Mulberry varieties, exploitation and pathology. *Sericologia*, **24**(3) : 333-359.
- SUSHEELAMMA, B. N., JOLLY, M. S., SHARMA, GIRIDHAR. K., DWIVEDI, N. K. AND SURYANARAYANA, N., 1988, Correlation and path analysis in mulberry under stress and non-stress conditions. *Sericologia*, **28**(2): 239-243.

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JOURNALS

- *Bulletin Of Indian Academy Of Sericulture*, CSTRI, Berhampore
- *Indian silk*, CSB, Bangalore
- *Journal of Sericultural Science of Japan*, Japan
- *Seridoc*, CSRTI (CSB), Mysore
- *Sericologia*, ISC, Bangalore
- *Korean Journal of Sericulture*, Korea
- *Indian Journal of Sericulture*, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

WEBSITES

- csb.gov.in/

- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 506

Title: Systematics and Morphology of Sericigenous insects

WHY THIS COURSE?

This course gives an impetus to study the morphological differences among sericigenous insects and to define new eco-races adopting morpho taxonomy, chemo taxonomy; to establish and explore new sericigenous fauna in different agro climatic zones.

AIM OF THE COURSE:

To inculcate basic systematics study among the students and to explore new fauna among sericigenous group of insects. Defining new genera, species and tribes in sericigenous insects in various habitats of different Agro-climatic zones of Karnataka/India

The course is organized as follows:

No	Blocks	Units
1	Morphological studies	1. Introduction to Morphology 2. Morphology of integument 3. Morphology of body segments and appendages
2	Systematics of sericigenous insects	1. Introduction, scope and methods 2. Type concept 3. Preparation of keys 4. Zoological nomenclature

LEARNING OUTCOMES:

After successful completion of this course the students are expected

- To identify the sericigenous fauna
- To understand the basic principles of morphology
- To understand the basic principles of systematics
- Understanding the Type concept, erection of types

- To establish confidence in systematics of sericigenous insects

Block 1: Morphological studies

Unit 1: Introduction to morphology

Introduction, general morphology with special reference to the morphology of sericigenous insects.

Unit 2: Morphology of integument

Structure, segmentation and outgrowths, body regions, appendages and other structures, their modifications in general.

Unit 3: Morphology of body segments and appendages

Morphology of head, thorax, abdomen and their appendages, antennae, mouthparts, setae, legs, cerci, styli and others. Morphology of reproductive organs – modifications.

Block 2: Systematics of sericigenous insects

Unit 1: Introduction, scope and methods

Introduction to systematics: Concept, scope and applications, methods involved in systematics.

Unit 2: Type concept

Holotype, syntype, erection of type and preservation of type.

Unit 3: Preparation of keys:

Key formation for sericigenous insects to identify orders, families, genera, species and tribes/eco-races.

Unit 4: Zoological nomenclature

Binomial nomenclature; concept, scope and application.

PRACTICALS

1. Study of head of sericigenous insects
2. Study of thorax and abdomen of sericigenous insects
3. Study of integument, their processes, outgrowths and setal maps
4. Preparation of temporary/permanent slides to study the processes
5. Drawing of sketches using grid and camera lucida
6. Collection and preservation of specimens – whole specimen, dry/wet preservation, labelling of the specimens
7. Study of type concept – Holotype, Syntype and allotype

8. Preparation of keys to orders, families, genera, species and tribes
9. Study of different sericigenous insects by making diagrams
10. Study of Chaetotaxy in sericigenous insects
11. Study of immature stages of silkworm *Bombyx mori* L.
12. Study of immature stages of Tropical Tasar silkworm
13. Study of immature stages of Eri silkworm
14. Study of Polymorphism in silkworm *Bombyx mori* L., Tropical Tasar and Eri silkworm
15. Field visits for collection of Non-mulberry silkworms
16. Collection and preservation of sericigenous insects (Dry preservation)
17. Collection and preservation of immature stages of sericigenous insects (Wet preservation)
18. Visit to Taxonomic section of department of entomology to understand preservation of specimens and their management

TEACHING METHODS / ACTIVITIES

- Lectures
- Collections, preservation of specimens and submission of different species of sericigenous insects
- Drawing of specimens – habitat sketches using camera lucida and grids
- Photography of specimens using scientifically advanced camera
- Micro photography / photo microscopy of specimens
- Preparation of permanent slides
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

DILIP DE SARKAR., 1998, *The Silkworm – Biology, Genetics and Breeding*. Vikas Publishing House Pvt. Ltd., New Delhi.

IMMS, A.D., 1961, *General Text Book of Entomology*. 9th Edn., Rev. by O.W. Richards & R.G. Davies, Bombay.

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SAXENA, A.B., 1996, *Ecology of Insects*. Anmol Publications Pvt. Ltd., New Delhi.

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- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 509

Course title: Silkworm Egg Production Technology

WHY THIS COURSE?

The silk cocoon yield and productivity directly depend on quality of silkworm eggs produced and distributed to the farmers. The silkworm egg production should be organized and handled scientifically for good quality disease free egg production at both seed and at commercial egg production. The present course is designed to make the student understand the organization of egg production and Acts associated with silkworm seed production, establishment of grainage, grainage equipments, activities, mother moth examination for disease free layings, egg incubation and preservation schedules, production of hybrid seeds and economics of egg production.

AIM OF THIS COURSE

The course is formulated with the aim of equipping the PG students with best scientific and practical knowledge on all the activities of egg production starting from organizational setup of seed production, grainage equipment, grainage activities, mother moth examination for producing student community of scientific and high technology expertise.

The course is organised as follows

No.	Blocks	Units
1.	Organization of egg production	1. Three tier multiplication of silkworm seeds 2. Seed Act
2.	Grainage	1. Establishment of grainage 2. Grainage activities
3.	Artificial Hatching of eggs	1. Production of hybrid eggs 2. Artificial methods of hatching

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Understand the organization of silkworm seed production structure, Grainage, silkworm egg production, seed act, artificial methods of hatching, egg incubation and hibernation schedules
- Utilize this knowledge in producing healthy and quality seed production, serve the farming community with scientific grainage techniques for quality egg production.

Block 1: Organization of egg production

Unit 1: Three tier multiplication of silkworm seeds

Organization of egg production. Breeder stock, foundation stock and commercial egg production (egg cards and loose egg preparation)

Unit 2: Seed Act

Seed legislative act, 1959. Seed Act 2010

Block 2: Grainage

Unit 1: Establishment of grainage

Location of grainage, plan of grainage, grainage equipments and capacity of grainage.

Unit 2: Grainage activities

Seed areas, seed cocoon market, procurement and transportation of seed cocoons, selection, storage, handling and processing of seed cocoons. Sex separation in pupal stage, moth emergence, synchronization of moth emergence, pairing, depairing, moth examination, laying preparation on egg cards/loose egg production, rejection of defective eggs, disinfection and washing and incubation of eggs.

Block 3: Artificial Hatching of eggs

Unit 1: Production of hybrid eggs

Production of hybrid seeds (Multivoltine x Bivoltine), (Bivoltine X Bivoltine), (Bivoltine X Bivoltine) X (Bivoltine X Bivoltine) (Double Cross Hybrid). Grainage pests. Economics of egg production and special determinants.

Unit 2: Artificial methods of hatching

Artificial methods of hatching of bivoltine eggs, cold and hot acid treatments, physical and chemical methods, hibernation schedules.

PRACTICALS

1. Silkworm breeds and their classification.
2. Study of ground plan of model grainage building.
3. Study of grainage equipments.
4. Preliminary examination of seed cocoons for production of dfls, study of handling and processing of seed cocoons.
5. Study of sex separation at pupal and adult stages
6. Study of Silkworm egg incubation
7. Study of silkworm egg hibernation schedules
8. Study of grainage pests and their management
9. Preservation of male moths for reuse
10. Preservation of male and female pupae for synchronization
11. Effect of mating duration on egg production and fertility status of eggs
12. Disinfection of grainage equipments
13. Designation of multivoltine and bivoltine seed areas in Karnataka
14. Estimation of cocoon requirement for production of unit number of DFLs
15. Production of non-hibernating eggs of silkworm
16. Production of hibernating eggs of silkworm (on egg cards and loose egg preparation)
17. Artificial hatching of silkworm eggs through acid treatment
18. Economics of silkworm egg production.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

1. ANONYMOUS., 1997, *Silkworm Egg Production*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
2. DANDIN, S.B. AND GUPTA, V.P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
3. DATTA, R.K., 1996, *Global Silk Scenario – 2001. Proceedings of the International Conference on Sericulture – 1994*, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
4. NARASIMHANNA, M.N., 1998, *Manual on Silkworm Egg Production*. CSB, Bangalore.

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- *Bulletin of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.
- *Current Science* – Published by Indian Institute of Science, Bangalore.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 510

Course title: Silkworm Rearing Technology

WHY THIS COURSE?

Silkworm rearing is the main contributing factor and plays a major role in quality cocoon production. It is important to know the different silkworm rearing methods for rearing young and late-age silkworms. The knowledge on scientific methods starting from egg incubation, black boxing, brushing, young age rearing, late age rearing, mounting of ripe silkworms, maintenance of environmental conditions during silkworm rearing, care during mounting etc., is very important for sericulture experts to lead the sericulture community with a scientific and technical expertise.

AIM OF THIS COURSE

The course is designed with the aim of equipping the PG students with the best scientific knowledge and technical expertise in the field of silkworm rearing technology, different methods / techniques involved in silkworm rearing, maintenance of environmental condition during rearing etc., for quality silkworm production inturn contributing to the economy of individual farmer.

The course is organised as follows

No.	Block	Units
1.	Planning for silkworm rearing	1. Planning for chawki rearing and late age silkworm rearing 2. Disinfection and disinfectants Mulberry leaf preservation 4. Incubation of silkworm eggs
2.	Silkworm rearing	1. Early instar silkworm rearing 2. Late age silkworm rearing
3.	Mounting, harvesting and marketing of silk cocoons	1. Mounting of ripe worms and cocoon marketing 2. Comparison of different rearing methods

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Understand thoroughly the scientific silkworm rearing techniques, scientific management of silkworms during special conditions like during mounting,

mulberry care, spinning stage etc., inturn contributing to build a technically competent Sericultural expertise.

BLOCK 1: Planning for silkworm rearing

Unit 1: Planning for chawki rearing and late age silkworm rearing

Planning for rearing, criteria to be considered for rearing, plan of rearing house for chawki and late age silkworm rearing, rearing equipment, measurement and regulation of environmental factors.

Unit 2: Disinfection and disinfectants

Disinfection of rearing room and equipment.

Unit 3: Mulberry leaf preservation

Planning for silkworm rearing; harvesting, transportation and preservation of mulberry leaves

Unit 4: Incubation of silkworm eggs

Different methods of incubation of silk moth eggs, black-boxing, hatching and brushing.

BLOCK 2: Silkworm rearing

Unit 1: Early instar silkworm rearing

Early instar silkworm (Chawki) rearing, different methods, environmental conditions, quality of leaf, feeding, bed cleaning, spacing. Chawki rearing centres.

Unit 2: Late age silkworm rearing

Different methods of late age silkworm rearing, environmental conditions, feeding and bed spacing. Management of silkworm during moulting.

BLOCK 3: Mounting,harvesting and marketing of silk cocoon

Unit 1: Mounting of ripe worms& cocoon marketing

Mounting of ripe worms, different kinds of mountages. Rearing house and equipment for shoot method of rearing.

Unit 2: Comparison of different rearing methods

Comparing shoot feeding and shelf method of rearing.

PRACTICALS

1. Ground plan for model rearing house for shelf method of rearing.

2. Chemical and physical agents used in silkworm rearing and disinfection.
3. Rearing equipments for shelf method of rearing.
4. Incubation of silk moth eggs and black- boxing
5. Hatching and brushing.
6. Early instar silkworm rearing
7. Late age silkworm rearing.
8. Regulation of environmental conditions for silkworm rearing.
9. Harvesting and preservation of mulberry leaf.
10. Management of silkworms during moulting.
11. Mounting of ripe silkworms.
12. Cocoon harvesting, grading, transportation and marketing
13. Rearing house and equipment for shoot method of rearing.
14. Shoot feeding for late age silkworm rearing.
15. Harvesting and preservation of mulberry shoots.
16. Spacing and bed cleaning in shoot feeding method of silkworm rearing.
17. Economics of silkworm rearing.
18. Rearing from brushing to mounting for seed and silk production.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

1. ANONYMOUS., 1998, *Illustrated Textbook on Sericulture*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
2. BORALIAH, G., 1994, *Lectures on Sericulture*. SBS Publishers, Bangalore.
3. DANDIN, S.B. AND GUPTA, V.P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
4. DANDIN, S.B., JAYANT JAYASWAL AND GIRIDHAR, K. (Eds.), 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore.
5. DATTA, R.K., 1996, *Global Silk Scenario – 2001. Proceedings of the International Conference on Sericulture – 1994*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

6. GOVINDAN, R., CHINNASWAMY, K.P., KRISHNAPRASAD, N.K. AND REDDY, D.N.R., 2000, *Advances in Tropical Sericulture. Vol. 4– Proceedings of NSTS – 1999*, UAS, Bangalore.
7. GOVINDAN, R., DEVAIAH, M.V. AND RANGASWAMY, H.R., 1978, *Reshme Vyavasaya (Kannada)*. UAS, Bangalore.
8. HIROO. AND SIBUYA-KU., 1975, *Textbook of Tropical Sericulture*. Japan Overseas Corporation Volunteers, Tokyo, Japan.
9. KRISHNASWAMI, S., NARASIMHANNA, M.N., SURYANARAYAN, S.K. AND KUMARARAJ, S., 1973, *Sericulture Manual-2 - Silkworm Rearing*. Agriculture Service Bulletin, FAO, Rome.
10. RAJAN, R.K. AND HIMANTHARAJ, H.T., 2005, *Silkworm Rearing Technology*. Central Silk Board, Bangalore.
11. RAMAKRISHNA NAIKA., GOVINDAN, R. AND SANNAPPA, B., 2002, *Organic Sericulture*. Seri Scientific Publishers, Bangalore.
12. TANAKA, Y., 1964, *Sericology*. Central Silk Board, Bangalore.
13. TAZIMA, Y., 1972, *Handbook of Silkworm Rearing*. Fuji Pub.Co. Ltd., Tokyo, Japan.
14. ULLAL, S.R. AND NARASIMHANNA, M.N., 1981, *Handbook of Practical Sericulture*. CSB, Bangalore.
15. YASUJI HAMAMURA., 2001, *Silkworm Rearing on Artificial Diet*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
16. YONEMURA, M. AND RAMA RAO, N., 1925, *Handook of Sericulture*. Mysore Government Branch Press.

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- *Bulletin of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
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- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.

WEBSITES

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- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 511

Title: Genetics and Breeding of Silkworms

WHY THIS COURSE?

Silkworm crop improvement needs sustainable efforts in order to achieve higher silk productivity of superior quality. Understanding of genetic basis of expression of characters and application of this understanding for breeding silkworms that meet the present day scenario is essential. Hence, this customised course.

AIM OF THIS COURSE

The course is designed to provide both basic and applied knowledge on the subjects of silkworm genetics and principles of silkworm breeding. The subject is addressed to understand reproductive biology, hereditary traits and principles of silkworm breeding

The course is organized as follows:

No	Blocks	Units
1	Genetics of silkworm	1. Cytology
		2. Reproductive biology
		3. Inheritance of characters
2	Breeding of silkworm	1. Silkworm breeding resources
		2. Methods of silkworm breeding

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Understand the reproductive biology, inheritance of traits and breeding methods
- Utilise this knowledge to plan for silkworm breeding activities.

BLOCK 1: Genetics of silkworm

Unit 1: Cytology

Ancestor and cytological basis of origin of silkworms. Cytological aspects of silk gland and achievements in deciphering molecular biology of silk gene. Hormonal control mechanisms.

Unit 2: Reproductive biology

Phenomena of spermatogenesis and oogenesis with relevance to crossing over, cell division types in silkworms, synaptonemal complex, fertilization, chromosomes in silkworms. Sex determination, parthenogenesis, polyploidy, mosaics.

Unit 3: Inheritance of characters

Hereditary traits of importance in egg, larva, pupa-cocoon and adult. E- Group as a tool in genetics & significance. Linkage groups in silkworms. Sex linked inheritance, Quantitative and Qualitative Characters in silkworm breeding. Genetics of cocoon colours. *Bombyx mori* L. genome and latest genome sequence, Translocation of characters in metamorphic stages.

BLOCK 2: Breeding of silkworm

Unit1: Silkworm breeding resources

Multivoltine & bivoltine races and hybrids. Silkworm germplasm and resource potential.

Unit2: Methods of silkworm breeding

Methods of silkworm breeding and their importance with relevance to Indian scenario. Breeding for thermotolerance, disease resistance, special characters required for the nation and also for silk export. Sex linked and sexlimited races- their importance and need of the hour, Authorization and release of silkworm races.

PRACTICALS

1. Study of mitosis and meiosis in silkworm
2. Study of oogenesis in silkworm
3. Study of spermatogenesis and fertilization in silkworms.
4. Study of important hereditary traits in egg and larva of silkworm *Bombyx mori* L.
5. Study of important hereditary traits of pupa and cocoons of silkworm *Bombyx mori*L.
6. Study of important hereditary traits of adult *Bombyx mori* L.
7. Study of Marker genes and linkage groups in silkworm.
8. Study of heterosis - working out heterosis, heterobeltiosis and standard heterosis for economic characters.
9. Study of silkworm germplasm
10. Study of biometrical methods in silkworm breeding,
11. Study of modern methods of silkworm breeding,
12. Study of induction of parthenogenesis in silkworm breeds
13. Study of induction of polyploidy in silkworm breeds
14. Study of conventional methods of silkworm breeding
15. Study of breeding of newly evolved silkworm breeds
16. Study of breeding of non-mulberry silkworms
17. Study of breeding plans
18. Visit to CSGRC,CSB, Hosur

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Visits to Germplasm centers
- Scientific journals and periodicals

RESOURCES

ANONYMOUS, 1993, *Principles and Techniques of Silkworm Breeding*. ESCAP, UN, New York. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. p.111.

GARDNER, E.J., SIMMONS, M.J. AND SNUSTAD, D.P., 1991, *Principles of Genetics*, John Willey & Sons Inc., New York. p. 649.

HIRATSUKA, E., 1999, *Silkworm Breeding*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. p. 500.

JOLLY, M.S., SEN, S.K., SONWALKER, T.N. AND PRASAD G.K., 1979, *Non-mulberry Silks*. FAO - Agricultural Service Bulletin, Rome. p. 178.

KOVALEV, P.A., 1970, *Silkworm Breeding Stocks*. Central Silk Board, Bombay. p. 233.
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SARIN, C., 1990, *Genetics*. Tata McGraw – Hill Publishing Co. Ltd., New Delhi. p. 528.
SINGH, B.D., 1997, *Plant Breeding: Principles and Methods*. Kalyani Publishers, New Delhi. p. 702.

SINGH, R.K. AND CHAUDHARY, B.D., 1996, *Biometrical Methods in Quantitative Genetic Analysis*. Kalyani Publishers, New Delhi. p. 318.

SREERAMAREDDY, G., 1998, *Silkworm Breeding*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

TAZIMA, Y., 1964, *The Genetics of Silkworm*. Logos Press Ltd., London. p. 253.

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- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.

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- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishhi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.
- *Current Science* – Published by Indian Institute of Science, Bangalore.

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- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 512

Title: Diseases and Pests of Silkworm

WHY THIS COURSE?

Silkworms are affected by a number of diseases caused by Microsporidia, fungi, viruses, bacteria and mixed infections and also attacked by insect pests. The exposure to these pathogens and pests results in mortality of silkworms and economic loss to the silkworm rearers. A better understanding of causative agents, symptoms, sources of infection, predisposing factors, transmission and management of silkworm diseases and pests is very important to improve cocoon productivity and maximize economic benefit to silkworm rearers by better avoidance/management of silkworm diseases and pests.

AIM OF THIS COURSE

The course is designed to provide both theory and practical knowledge regarding the subjects of Classification of disease-causing organisms of mulberry and non-mulberry silkworms including viral, fungal, bacterial, protozoan and mixed infections. Knowledge on their occurrence, causative agent, etiology, symptoms and infection, sources of infection, predisposing factors, transmission and management, symptoms, seasonal incidence of diseases associated with mulberry and non-mulberry silkworms is important. Diagnosis of different pathogens based on symptoms (external and internal), regulation of environmental factors contributing to diseases, prevention and control of diseases also attain importance. Know how

on pests of mulberry and non-mulberry silkworms, uzi fly occurrence, nature and extent of damage, life-cycle and management, other pests and predators effecting silkworm crop and their management and pesticide toxicity /residual toxicity, use of eco-friendly pesticides and biological control will also be dealt.

The course is organized as follows:

No	Blocks	Units
1	Silkworm diseases and their management	1.Importance and Classification
		2.Silkworm pathogens, disease development and diagnosis
		3.Management of silkworm diseases
2	Silkworm pests and their management	1. Ujifly, <i>Exorista bombycis</i> Louis - a major pest of silkworms.
		2. Other pests and predators affecting silkworm crop and their management.
		3. Pesticide toxicity

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Appreciate the scientific foundation of silkworm protection and relate the key learning for further scientific research in the area of silkworm protection.
- Utilise methods and tools for prevention and management of diseases and pests of silkworms
- Utilise material in scientific publications relevant for silkworm protection for enhancing cocoon crop productivity through effective management of silkworm diseases and pests.

BLOCK 1: Silkworm diseases and their management

Unit 1: Importance classification

Taxonomic position of silkworm disease causing organisms including viruses, bacteria, fungi, protozoans, classification of various pests causing economic loss to silkworms, and their importance.

Unit 2: Silkworm pathogens, disease development and diagnosis

Occurrence, causative agent, symptoms and infection, source of infection, predisposing factors, seasonal incidence, transmission and management of the pathogens individually including viral, fungal, bacterial, protozoan and mixed infections. Diagnosis of different pathogens based on symptoms (external and internal), patho-physiology and histopathology.

Unit 3: Management of silkworm diseases

Comparative etiology of silkworm pathogens. Management, prevention and control of diseases of silkworms, regulation of predisposing and environmental factors contributing to diseases, rearing disease resistant breeds of silkworm. Management of alternative hosts of silkworm disease causing pathogens (Lepidopteran crop pests and pests of mulberry). Intergrated disease management.

BLOCK 2: Silkworm pests and their management

Unit 1: Uji fly, *Exorista bombycis* Louis - a major pest of silkworms

History and taxonomy, Bio-ecology, Life cycle-egg, maggot, pupa, adult, oviposition, damage and extent of damage caused, prevention and control, biological control and IPM.

Unit 2: Other pests and predators affecting silkworm crop and their management.

Pests and predators causing loss to silkworms and cocoons including Ants, type of damage, management. Straw itch mite, life cycle, kind of damage, management.

Dermestid beetles, classification, life cycle, nature of damage, management. Rats, squirrels, lizards, earwigs, etc.,

Unit 3: Pesticide toxicity

Poisoning by agricultural chemicals to silkworms, acute and chronic symptoms of poisoning by different agricultural chemicals. Residual toxicity of chemicals on mulberry and damage caused, prevention and control.

PRACTICALS

1. Sterilization techniques for isolation of silkworm pathogens
2. Isolation and purification of *BmNPV*
3. Isolation and purification of *BmCPV*
4. Isolation and purification of *BmIFV* and *BmDNV*
5. Isolation and purification of white muscardine fungus *Beauveria bassiana* from silkworm *Bombyx mori*
6. Isolation and purification of brown muscardine fungus *Aspergillus tamaritii* from silkworm *Bombyx mori*
7. Isolation and purification of bacteria from the gut and haemolymph of silkworm

Bombyx mori

8. Study of life cycle, symptoms and diagnosis of *BmNPV*.
9. Study of life cycle, symptoms and diagnosis of *BmCPV*.
10. Study of life cycle, symptoms and diagnosis of *BmIFV* and *BmDNV*.

11. Study of life cycle, symptoms and diagnosis of silkworm microsporidiosis
12. Study of life cycle, symptoms and diagnosis of white and green muscardines
13. Study of bacteria invading the digestive system and haemolymph.
14. Study of bacterial toxicosis in mulberry silkworm.
15. Intergrated management for prevention of silkworm diseases.
16. Study of life-cycle of silkworm ujjfly and its management.
17. Study of life cycle and management of dermestid beetles.
18. Visit to sericulture farmers fields

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

GOVINDAN, R., NARAYANASWAMY, T. K. AND DEVAIAH, M. C., 1998, *Principles of Silkworm Pathology*, p.420

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NATARAJU, B., SATHYAPRASAD, K., MANJUNATH, D. AND ASWANI KUMAR, C.,2005, *Silkworm Crop Protection*. Central Silk Board, Bangalore, pp. 1-285

PRINGLE JAMESON, A., 1984, *Report On The Diseases Of Silkworms In India*, IBS, New Delhi, pp. 1-64.

JOURNALS

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- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.

- *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.

Websites

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- www.csrtimys.res.in/

Credits: 1+1

Course code: SER 514

Course Title: Silk Technology-I

WHY THIS COURSE?

Sericulture is an agro based industry, which concentrates on production of quality leaf, cocoon and raw silk. The raw silk production by reelers from different machineries plays an important role in fabric production. Therefore, cocoon is considered as raw material for silk reeling industry which has to be processed by adopting recent techniques in all aspects of reeling that aim at quality raw silk production. The knowledge on recent techniques serves as an effective tool in reeling cocoons which throws light to produce competitive technical man power in processing of raw material. Hence is this course.

AIM OF THE COURSE

The course is designed to make the students to get acquainted with activities in different reeling units operated both in private and government sectors. These activities will help in learning all techniques of silk reeling for quality raw silk production. In addition, they get knowledge on responsibilities of reeling units on management of labour and exploitation of reeling waste generated for by-product utilization.

Organisation of course:

Sl.No.	Blocks	Units
1	Cocoon as raw material	1. Physical characteristics 2. Commercial characteristics
2	Transaction of cocoons	1. Defective cocoons 2. Cocoon marketing
3	Steps in silk reeling	1. Cocoon stifling 2. Cocoon cooking and brushing 3. Cocoon reeling

		4. Re-reeling 5. Reeling water
4	Silk testing and examination	1. Different methods of silk examination 2. Silk testing and grading
5	Post reeling technology	1. Doubling, twisting and weaving 2. Marketing of raw silk.

LEARNING OUTCOMES:

After undergoing this course the students are able to assess the quality of cocoon as raw material for reeling industry and acquaint with different techniques of reeling in quality silk production.

BLOCK 1: Cocoon as raw material

Unit 1: Physical characteristics

Introduction; Importance and use of silk, cocoon quality. Physical characteristics-cocoon colour, shape, size, wrinkles, uniformity and compactness.

Unit 2: Commercial characteristics

Cocoon weight, shell weight, shell percentage, filament length, denier, non-breakable filament length, reelability and raw silk percentage.

BLOCK 2: Transaction of cocoons

Unit 1: Defective cocoons

Types of defective cocoons, reasons for defective cocoons, cocoon sorting, methods of sorting, estimation of defective cocoons per kg. Technological aspects. Selection of raw material for silk reeling - scientific method of testing and classification of cocoons.

Unit 2: Cocoon marketing

Marketing based on visual observation and based on quantitative parameters, open auction system (Quality based pricing) and E- transaction. Limitations of open auction system and estimation of renditta.

BLOCK 3: Steps in silk reeling

Unit 1: Cocoon stifling

Definition, different methods of stifling of cocoons - sun drying, steam stifling, hot air drying (shelf carrier type, Tunnel type, Band type- hot air circulating, air heating type and one step band type) and other methods. Effect of storage on stifling. Moisture percentage, Phenomenon of cocoon drying, drying percentage, equilibrium moisture percentage

(Phenomenon of moisture evaporation). Effect of cocoon thickness and compactness on cocoon stifling, advanced system of cocoon stifling and machineries.

Unit 2: Cocoon cooking and brushing

Cocoon cooking- objectives of cocoon cooking, effect of pressure and temperature on infiltration of water into cocoon cavity, swelling of sericin layer, different methods of cooking (Open pan, two pan and three pan cooking system). Brushing of cocoons, different methods of

brushing. Effect of temperature on solubility of sericin and fibroin layers, dipping period and brushing.

Unit 3: Cocoon reeling

Cocoon reeling- definition, different methods of reeling (Open/ Floating/ Sunken), Importance of croissure, length of the croissure and croissure angle and silk reeling, reeling machineries –Silk reeling on charaka, cottage basin, multiend, semi automatic and automatic reeling machines.

Unit 4: Re-reeling

Re-reeling, reel permeation, different methods of permeation, re-reeling methods, advantages and disadvantages of open re-reeling and closed type of re-reeling

Unit 5: Reeling water

Reeling water: Different sources of water used in reeling, characteristics/Properties of water (Impurities of water), Physical and chemical properties of water, Importance of reeling water, water qualities suggested by Kim and amelioration of water, different methods of amelioration (aeration, filtration, sedimentation and ion exchange method), amelioration of reeled water and reuse of water after treatment.

BLOCK 4: Silk testing and examination

Unit 1: Different methods of silk examination

Different silk examination methods and lacing, book and bale making.

Unit 2: Silk testing and grading

Silk testing and grading-grading of raw silk based on I.S.A., silk testing tools for physical (visual inspection) and mechanical properties of silk. Procedure adopted for conducting physical and mechanical properties of silk and equipments used for testing of raw silk.

BLOCK 5: Post reeling technology**Unit 1: Doubling, twisting and weaving**

Silk throwing, weaving, warping and wefting, silk doubling and twisting, by-products of reeling units, types of reeling waste (brushing waste, reeling waste, cooking waste, re-reeling waste, throwing waste and pelade layer) as raw material for spun silk industry.

Unit 2: Marketing of raw silk.

Factors influencing the assessment of raw silk quality. Role of silk exchange, auctioning of raw silk based on physical and mechanical properties and economics of silk reeling.

PRACTICALS:

1. Classification of cocoons of silkworm breeds
2. Study of Physical and Commercial characters of cocoons
3. Study of mode and time of cocoon transportation and marketing
4. Cocoon sorting, methods and estimation of defective cocoons
5. Cocoon stifling methods and estimation of drying and moisture percentage
6. Practising of cocoon cooking and brushing methods
7. Estimation of reeling and cooking waste percentage
8. Reeling appliances and practising reeling on Charaka and improved Charaka
9. Study of reeling appliances and practising reeling on Cottage basin and Domestic basin
10. Visit to government filature to acquaint with large scale reeling on Multiend reeling machine
11. Visit to Automatic reeling machine unit at Ramanagara
12. Silk examination, skein making and book making.
13. Study of Reeling water and its quality
14. Amelioration of silk reeling water and its importance
15. Study of physical properties of mulberry raw silk
16. Study of microscopic examination of silk bave
17. Study of quality tests of raw silk and By-products in silk reeling
18. Visit to Central silk technological research institute, Bengaluru

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations

- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES:

- Bhaskar, R. N. And Govindan, R., 2005, Techniques in Silk Reeling, Department of Sericulture, UAS,GKVK,p. 50
- Ganga, G., 2003, *Comprehensive Sericulture. Volume 2. Silkworm Rearing and Silk Reeling.*Oxford & IBH, New Delhi, p.429.
- Kamal Jaiswal, Sunil P. Trivedi, Pandey, B. N. And Tripathi, A. K., Mulberry sericulture problems and prospects,A P H publishing corporation, New Delhi-110 002.
- Kim, B. H.,1978, Raw Silk Reeling, Korean edition Seoul Publishing Company, P 275
- Krishnaswami, S., Madhava Rao, N.R. Suryanarayan, S.K. And Sundaramurthy, T.S., 1972, *Manual on Sericulture-III.Silk Reeling*, FAO, Rome, p.112.
- Mahadevappa, D., Halliyal, V. G., Shankar, A. G. And Ravindra Bhandiwad, Mulberry silk reeling technology, Oxford & IBH publishing Co. Pvt. Ltd.
- Manual on Bivoltine silk Reeling Technology, 2003 published by JICA, PPP BST Project, p.122
- Savithri, Sujathamma And Neeraja, Sericulture Industry: An Overview.
- Tripurari Sharan, Sericulture and silk industry, Consortium on rural technology, Madhuvan, Delhi- 110092.

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- *Bulletins of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 515

Title: Non-mulberry Sericulture

WHY THIS COURSE?

This course enlightens various types of silk producing insects viz., Tasar, Eri and Muga and their production techniques. This highlights wild rearing in-situ in forest area and also semi domestication of wild non-mulberry silks. This also helps to explore possibilities of new sericigenous insects and other minor silk producers.

AIM OF THE COURSE:

This course is designed to provide basic and applied aspects of non-mulberry sericulture. This course will approach multi-disciplinary perspective, it aims to equip students to identify, evaluate and explore new species of sericigenous insects to address the tribals self employment programme.

The course is organized as follows:

No	Blocks	Units
1.	Underexploited non-mulberry silks	1. Scope, importance, distribution in the World 2. Introduction to Anaphe, Coan and Fagara silks
2.	Commercially exploited non-mulberry silks	1. Scope, importance and their distribution in the World 2. Rearing of Eri silkworms 3. Rearing of Tasar (tropical/temperate) 4. Rearing of Muga silkworms 5. Economics of non-mulberry silkworm rearing

LEARNING OUTCOMES:

After successful completion of this course the students are expected to be able to

- acquire skills on rearing of vanya silks, their host plants and rearing technologies. In addition, it enables to explore less known silkworm species and exploit them.

BLOCK 1: Underexploited less known non-mulberry silks

Unit 1: Scope, importance and distribution in the World

Uses of less known sericigenous species for commercial exploitation, distribution pattern on different host plants and their statistics.

Unit 2: Introduction to Anaphe, Coan and Fagara silks

Systematics, morphology and cocoon characteristics of Anaphe, Fagara, Coan silks and possibilities of their exploitation

BLOCK 2: Commercially exploited non-mulberry silks

Unit 1: Scope, importance and their distribution in the world

Scope, importance, distribution in the country and World of Eri, Tropical Tasar, Temperate Tasar and Muga silks and their primary and secondary host plants.

Unit 2: Rearing of Eri silkworm

Host plant distribution and their classification, agronomic practices and their protection, grainage techniques, rearing of eri using improved techniques and crop protection.

Unit 3: Rearing of Tasar (tropical/temperate)

Host plant distribution and their classification, agronomic practices and their protection, grainage techniques, rearing of tropical / temperate tasar using improved techniques and crop protection.

Unit 4: Rearing of Muga silkworms

Host plant distribution and their classification, agronomic practices and their protection, grainage techniques, rearing of muga silkworms using improved techniques and crop protection.

Unit 5: Economics of non-mulberry silkworm rearing

Economics of non-mulberry silkworm rearing *viz.*, eri, tasar and muga silkworm rearing and their cost benefit ratio.

PRACTICALS

1. Study of primary and secondary host plants of eri silkworm
2. Study of primary and secondary host plants of tasar silkworm
3. Study of primary and secondary host plants of muga silkworm
4. Cultivation of popular castor genotypes for eri silkworm rearing
5. Preparation of rearing house for eri silkworm rearing
6. Rearing of eri silkworm on different castor genotypes
7. Calculation of consumption indices in eri silkworm using leaves of different castor genotypes

8. Collection and dry preservation of different primary & secondary host plants of non-mulberry silkworms
9. Preparation of disease free layings of eri silkworm
10. Morphology of eggs and larvae of eri silkworm
11. Morphology of pupa and moth of eri silkworm
12. Morphology of eggs and larvae of tasar and muga silkworms
13. Morphology of pupa and moth of tasar and muga silkworms
14. Effect of different mating durations on fecundity and fertility of eri silk moths
15. Study of different natural enemies of eri silkworm
16. Study of different diseases of eri silkworm
17. Practising of tasar egg production
18. Economics of eri silkworm rearing
19. Visit to Eri Silkworm Seed Production Centre, CSGRC Hosur, CSB.

TEACHING METHODS / ACTIVITIES

- Lectures
- Collections of various non-mulberry silkworms
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

- JOLLY, M.S., SEN, S.K. AND AHSAN, M.M., 1974, *Tasar culture*. Ambika Publishers, Bombay.
- JOLLY, M.S., SEN, S.K., SONWALKAR, T.N. AND PRASAD, G.K., 1979, *Sericulture Manual - 4 – Non-Mulberry Silks*. Agriculture Service Bulletin, FAO, Rome.
- SANNAPPA, B., JAYARAMAIAH, M., GOVINDAN, R. AND CHINNASWAMY, K.P., 2002, *Advances in Sericulture*. Seri Scientific Publishers, Bangalore. SARKAR, D.C., 1980, *Sericulture in India*. Central Silk Board, Bangalore

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- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Sugunami-ku, Tokyo, Japan.

- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/ www.csrtimys.res.in/

Credits: 1+1

Course code: SER 503

Title: Nutrition of Host Plants of Silkworms

WHY THIS COURSE?

Silkworm is monophagous insect mainly feeding on mulberry and drawing its nourishment for growth and development. It is mainly dependent on the quality of leaf used for silkworm rearing. Production of quality leaf by adopting standard package of practices to increase biochemical parameters of mulberry which are directly involved not only to improve the quality parameters but also enhance productivity per unit area. Therefore, the technical knowledge on nutritional management of mulberry definitely helps in improving quality parameters of silk. Hence this course.

AIM OF THE COURSE

The main aim of this course is to provide both basic and applied knowledge on nutritional management through different methods and means of application. Further, it also provides nutritional requirement for different growth stages which is required for silkworm growth and development. In addition, the complementary use of chemicals, fertilizers, organic manure and bio-fertilizer is important to maintain and sustain higher level of soil fertility and productivity. The principles of manure and fertilizer application and their toxicity affect on quality parameters of mulberry is the need of the hour. The beneficial effect of optimum nutrition and toxicity due to excess nutrients application and deficiency symptoms due to lack of nutrient availability affect the growth of mulberry. The academic knowledge on the above helps in strengthening the skills of students to serve the farming community effectively who are involved in quality leaf production and success of sericulture.

Organisation of course:

Sl.No.	Block	Units
1	Organic manure application	1. Principles of manure application
2	Nutrition of non-mulberry silkworm host plants	1. Nutrition of non-mulberry silkworm host plants
3	Physico-chemical properties of soil and Nutrient uptake	1. Influence of physical and chemical properties of soil
4	Application of major nutrients	1. Principles of fertilizer application. 2. Role of nitrogen 3. Role of Phosphorus 4. Role of Potash 5. Role of secondary nutrients
5	Nutrient deficiency	1. Nutrient deficiencies and toxicity of nutrients

LEARNING OUTCOME:

After the successful completion of this course the students are expected to:

- ✓ Assess the quantity of manures and fertilizers requirement for rainfed and irrigated mulberry
- ✓ Identify the deficiency symptoms of major and micro nutrients
- ✓ Adopt IPNM model for productivity enhancement

BLOCK 1: Organic manure application**Unit 1: Principles of manure application**

Role of mineral nutrition on growth and development of mulberry, Classification of minerals i.e. organic and inorganic, Types of organic nutrition –FYM, Compost, Pressmud, Animalmanure- Poultry manure, piggery manure, Horse manure, methods of green manuring and composting.

BLOCK 2: Nutrition of non-mulberry silkworm host plants

Unit 1: Nutrition of non-mulberry silkworm host plants Nutritional aspects of Castor, Tapioca, Terminalia, Soalu and Som

BLOCK 3: Physico-chemical properties of soil and Nutrient uptake**Unit 1: Influence of physical and chemical properties of soil**

Types of mulberry soils, soil structure, texture, CEC, clay and mineral composition, soil pH, micro and macro fauna, organic matter and their influence on growth and development.

Role of physical and chemical properties on nutrient uptake and growth. Absorption pattern of major and micro nutrients in different soils. Response of mulberry varieties on absorption pattern of N, P, K and micronutrients.

BLOCK 4: Application of major nutrients**Unit 1: Principles of fertilizer application**

Role of bio-fertilizers –Nitrogen fixing bacteria, phosphate solubilizing fungi, exploitation of K solubilizing organism, VAM, application methods, split application based on soil test for both rainfed and irrigated conditions.

Unit 2: Role of nitrogen

Sources of nitrogen, types and method of application on growth and development and biochemical constituents of mulberry and their effect on rearing parameters.

Unit 3: Role of Phosphorus

Sources of Phosphorus, types and methods of application on growth and development and biochemical constituents of mulberry and effect on rearing parameters.

Unit 4: Role of Potash

Sources of Potash, types and methods of application on growth and development and biochemical constituents of mulberry and effect on rearing parameters.

Unit 5: Role of secondary nutrients

Sources of secondary nutrients, types and methods of application on growth and development and biochemical constituents of mulberry and effect on rearing parameters.

BLOCK 5: Nutrient deficiency**Unit 1: Deficiencies of Major nutrients and their toxicity**

Deficiency symptoms of N, P and K toxicity in mulberry plants and their effect on quality of mulberry, correction of the soil by soil application, foliar application and fertigation methods.

Unit 2: Deficiencies of Secondary nutrients and their toxicity

Deficiency symptoms of S, Mn, Fe, Mo, Mg, Ca, Zn and other micronutrients and their toxicity in mulberry plants and their effect on quality of mulberry, correction of the through soil and foliar application and fertigation.

PRACTICALS

1. Collection of soil samples in mulberry garden and interpretation of soil test results
2. Development of recommended fertilizer schedule for both rainfed and irrigated mulberry
3. Modern methods of vermin-composting techniques by using sericulture wastes
4. Different methods of green manuring and conservation practices
5. Growth and root parameters of mulberry under different moisture regimes
6. Estimation of mulberry yield per unit area in both rainfed and irrigated condition
7. Use of soil amendments on sprouting and rooting pattern in mulberry
8. Pot culture studies on the effect of nutrient solution and bacterial inoculants on the growth of mulberry cuttings.
9. Enumeration of beneficial microflora (Bacteria, Fungi and Actinomycetes) in mulberry rhizosphere
10. Induction of deficiency symptoms of major nutrients using sand culture techniques
11. Practising of foliar nutrient application in mulberry
12. Application of conventional methods of fertilizer application in mulberry
13. Practising supply of nutrients to mulberry through fertigation
14. Study of different methods of fertilizer application in mulberry

15. Study on effect of fertilizer use pattern on physico-chemical properties of mulberry soil
16. Supplementation of deficit nutrients for both rainfed and irrigated mulberry schedule as per soil test
17. Enumeration of micro fauna of soils under mulberry cultivation
18. Study of fertilizer use efficiency in mulberry
19. Practising Seri Suvarna Technology (Trenching and Mulching) in mulberry garden

TEACHING METHODS / ACTIVITIES

- Lectures
- Providing study material / lecture material
- Practical manuals
- Assignments (Reading/Writing)
- Text Books / Publications / reviews/technical bulletins/manuals/proceedings of scientific seminars
- Student presentations
- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals
- Layout of experiments
- Study visits

RESOURCES:

- Bongale, U.D., 2003, Nutritional Management and quality improvement in sericulture, Proceedings of the national seminar on mulberry sericulture research in India (26th to 28th November 2001),P-1037
- Dandin, S.B. And Giridhar, K,2014, *Handbook of Sericulture Technologies*,CSB, Bengaluru,P-427
- Ganga, G., 2003, Comprehensive Sericulture. Volume 2. Silkworm Rearing and Silk Reeling. Oxford & IBH, New Delhi, P.429.
- Rajanna.L., Das, P.K.,Ravindran,S. ,Bhogesha,K., Mishra, R.K., Singhvi, N. R., Katiyar, R. S. And Jayaram, H.,2005, *Mulberry cultivation and physiology*, Central Silk Board, Bangalore, P-367.
- Rangaswamy, G. Narasimhanna, M. N., Kasiviswanathan, K. And Sastry, C. R.1976, Manual on Sericulture-I.Mulberry cultivation, FAO, Rome, P.150
- Nutritional Management and Quality improvement in sericulture, 2003, KSSRDI. Bangalore.

Zheng Ting-Zing, Tan Yun-Fang, Huang Guang-Xian, Fan Huaizhong And Ma Ben, *Mulberry cultivation*, Oxford & IBH publishing Co. pvt. Ltd., New delhi, Bombay and Calcutta.

Ninge Gowda, K. N., *Morphology of mulberry*. Bangalore University, Bangalore
Kichisaburo Minamizawa, *Moriculture- Science of mulberry cultivation*

JOURNALS

1. *Bulletins of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
2. *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
3. *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
4. *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
5. *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
6. *Indian Silk* - Published by Central Silk Board, Bangalore.
7. *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
8. *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.
9. *Current Science* – Published by Indian Institute of Science, Bangalore.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Credit: 2+1

Course Code: SER 504

Course Title: Mulberry Pests and Diseases

WHY THIS COURSE?

Mulberry is key a factor in the production of quality silk cocoon by the silkworm rearers. As nutrient rich silkworm food crop the mulberry also attracting various pests and suffers from diseases. The knowledge on various important pests and diseases affecting mulberry in different seasons, symptoms, their life cycle and different management practices are necessary for quality mulberry leaf production economically. Hence, is this course.

AIM OF THE COURSE

The course is designed to provide both basic and applied knowledge in managing diseases and pests in mulberry eco-system. It helps to equip students to understand different pests infesting mulberry crop at different stages and seasons, diseases affecting mulberry crop and their management so that producing technically competent sericulture manpower for leading sericulture formats towards scientific quality mulberry production.

This course is organized as follows:

No	Blocks	Units
1	Mulberry diseases and their management	1. Fungal diseases
		2. Bacterial diseases
		3. Viral diseases
		4. Nematode diseases
2	Mulberry pests and their management	1. Leaf eating pests (Defoliating pests)
		2. Sucking pests (Sap feeders)
		3. Other Minor pests of mulberry

LEARNING OUTCOMES

After successful completion of this course, the students are expected be able to:

- Understand the nature of pest and diseases of mulberry, their occurrence, symptoms, damage caused at different stages of the mulberry plant
- Learn different management practices for pest and diseases in mulberry and use this knowledge for successful mulberry leaf production.

BLOCK1: Mulberry diseases and their management

Unit1: Fungal diseases

Root rot diseases, powdery mildew, leaf spot and leaf rust diseases. Classification, occurrence, symptoms and damage, extent of crop loss and management.

Unit2: Bacterial diseases

Leaf blight and Rot diseases-Classification, occurrence, symptoms of damage extent of crop loss and management.

Unit3: Viral diseases

Leaf mosaic and mulberry dwarf diseases classification, occurrence, symptoms extent of crop loss and management.

Unit4: Nematode disease

Root knot diseases- Classification, occurrence, symptoms, identification of root knots extent of crop loss and management.

BLOCK-2: Mulberry Pests and their Management**Unit1: Leaf eating pests (Defoliators)**

Mulberry leaf roller, Bihar hairy caterpillar, wingless grasshopper, cutworm, rootgrubs -Classification, status, seasonal incidence, damaged caused symptoms, loss, lifecycle and management.

Unit2: Sap feeders (Sucking pests)

Thrips, jassids, spiraling whitefly, scale insects, mealy bugs, spider mites -Classification, status, seasonal incidence, damaged caused symptoms, loss, lifecycle and management.

Unit3: Minor pests of mulberry

Stem borer, termites, May-June beetles, stem girdler beetle - RotsClassification, status, seasonal incidence, damaged caused symptoms, loss, lifecycle and management.

PRACTICALS

1. Collection of insect and non-insect pests from mulberry garden and their preservation
2. Classification of mulberry pests based on taxonomy and nature of feeding
3. Classification of mulberry diseases
4. Collection of diseased specimen from mulberry garden and their preservation
5. Classification of mulberry diseases based on taxonomy and parts of the plants damaged
6. Incidence and estimation of damage to mulberry caused by mulberry leaf webber
7. Incidence and estimation of damage to mulberry caused Bihar Hairy Caterpillar
8. Study of life cycle of mulberry leaf webber
9. Study of life cycle of Black Headed Hairy Caterpillar
10. Study of life cycle of mulberry leaf spot
11. Study of life cycle of mulberry leaf rust
12. Study of life cycle of powdery mildew of mulberry
13. Isolation of leaf spot fungus and bacterial blight pathogen in the laboratory and characterization
14. Varietal response of mulberry to root knot nematode disease
15. Incidence, symptoms and damage of Tukra disease on different varieties of mulberry
16. Life cycle of wingless grasshopper and cutworm on mulberry
17. Incidence of thrips on the available varieties of mulberry

18. Collection of specific predators and parasites in mulberry garden, preservation and their classification
19. Diseases and pests associated with mulberry nursery and tree mulberry
20. Commonly used insecticides and fungicides in mulberry garden- classification, forms, formulations and their applications

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals / Publication reviews
- Study visits

RESOURCES

- Bilgrami, K.S. And Dube, H.C., 1997, *A Textbook of Modern Plant Pathology*. Vikas Publishing House Pvt. Ltd., New Delhi.
- Gautam, R.D., 1994, *Biological Pest Suppression*. Westvill Publishing House, New Delhi.
- Ghosh, M.R., 1989, *Concepts of Insect Control*. New Age International Publishers, New Delhi.
- Govindan, R., Ramakrishna Naika And Sannappa, B., 2004, *Advances in Disease and Pest Management in Sericulture*. Seri Scientific Publishers, Bangalore.
- Govindan, R., Ramakrishna Naika And Sannappa, B., 2004, *Progress of Research on Disease and Pest Management in Sericulture*. Seri Scientific Publishers, Bangalore.
- Huang, E., 2003, *Protection of Mulberry Plants*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- Metcalf, C.L., Flint, W.P. And Metcalf, R.L., 1962, *Destructive and Useful Insects*. MacGraw-Hill Book Co. Inc., New York and London.
- Narayanaswamy, K.C. And Devaiah, M.C., 1998, *Silkworm Uzi Fly*. Zen Publishers, Bangalore.
- Nataraju, B., Sathyaprasad, K., Manjunath, D. And Aswani Kumar, C., 2005, *Silkworm Crop Protection*. Central Silk Board, Bangalore.
- Rangaswami, G., 1996, *Diseases of Crop Plants in India*. Prentice Hall of India Pvt. Ltd., New Delhi.

- Reddy, D.N.R. And Narayanaswamy, K.C., 2003, *Pests of Mulberry*. Zen Publishers, Bangalore.
- Sengupta, K., Kumar, P., Baig, M. And Govindaiah, 1990, *Handbook on Pest and Disease Control of Mulberry and Silkworm*. ESCAP, UN, Thailand.
- Singh, R.N., Samson, M.V. And Datta, R.K., 2000, *Pest Management in Sericulture*. Indian Publishers, Delhi.
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3. *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
4. *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
5. *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
6. *Indian Silk* - Published by Central Silk Board, Bangalore.
7. *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
8. *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.

WEBSITES

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- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits : 1+1

Course code: SER 505

Course Title: Biotechnology of Mulberry

WHY THIS COURSE?

Mulberry is perennial and highly heterozygous crop. Hence, selection in segregating progenies is very difficult. In order to aid the selection in mulberry, the biotechnological tools viz., Tissue culture techniques, molecular markers and recombinant DNA technology are more useful

to aid in selection. Application of these techniques will shorten the breeding procedure. Hence this customised course.

AIM OF THIS COURSE:

The course is designed to provide both basic and applied knowledge on the subjects of Tissue culture techniques, molecular markers and recombinant DNA technologies to PG students.

The course is organised as follows:

No.	Blocks	Units
1	Mulberry biotechnology, scope and prospects	1. Mulberry biotechnology, scope and prospects
		2. Mulberry germplasm characterization
		3. Genotyping and phenotyping
2	Recombinant DNA technology	1. Genes transfer systems
		2. QTL mapping
		3. Seri bioinformatics

BLOCK 1: Mulberry biotechnology, scope and prospects

Unit 1: Mulberry biotechnology, scope and prospects.

Scope of breeding for hardier and productive mulberry genotypes. Preservation of genetic material. Development of transgenic mulberry. Molecular linkage map of mulberry. Micropropagation: *In vitro* propagation in mulberry-production of haploids- induction of haploids, advantages and disadvantages of haploids. Double haploids -induction, advantages and disadvantages of double haploids. Practical achievements of DH method, polyploids-Somaclonal variations, Procedures, advantages, disadvantages and their applications. Secondary metabolites. Gameto clonal variations - their scope and applications. Cryopreservation: Definition and meaning, Steps in cryopreservation, Advantages and disadvantages, Cryopreservation Requirements, applications of cryopreservation in mulberry for germplasm preservation.

Unit 2: Mulberry germplasm characterization

Mulberry germplasm characterization by using molecular markers. Introduction, features of ideal DNA markers, types of DNA markers, uses in crop improvement. Application of biotechnological tools in screening for biotic and abiotic stress tolerance in mulberry.

Unit 3. Genotyping and phenotyping

Introduction, definition of genotype and phenotype. Phenotyping- advantages and disadvantages. Methods of genotyping, advantages and disadvantages of genotyping and applications of genotyping. Marker Aided Selection (MAS) for economically important traits in mulberry. Steps involved in MAS. Application of MAS, advantages of MAS, limitations of MAS.

BLOCK 2: Recombinant DNA technology

Unit 1: Genes transfer systems

Vector mediated gene transfer, microinjection, electroporation, direct DNA uptake, gene gun technique, selectable markers and reporter system; comparison of transgenic technology and traditional breeding methods, detection of transgenic mulberry. Prospects of transgenic mulberry. Procedure of development of transgenic mulberry. Advantages and disadvantages of transgenic mulberry. Risks in transgenic technology. Biosafety and regulatory issues, Achievements.

Unit 2: QTL mapping

Development of maps, Advantages and limitations of QTL mapping. Methods of mapping. Requirements and steps involved in QTL mapping. Mapping populations (F₂S and back crosses RILs, NILs, DHs). Tagging of economically important traits in mulberry.

Unit 3: Seri bioinformatics

Bioinformatics in crop improvement-introduction, branches of bioinformatics, computer programmes used in biology, applications in crop improvement, varietal information system, PGR data base. Studies on Genomics- genomics in crop improvement, types of genomics: structural, functional and applications, achievements and limitations. Studies on proteomics. Studies on metabolomics, advantages of bioinformatics, limitations. Intellectual Property Rights. Plant variety protection act (PVPA): introduction, types of protection, basic requirements, organizations involved, procedure of PVP, material to be protected, types of varieties, exemptions under PVPA, advantages and disadvantages of PVPA. Nano- technology: introduction, main features, Application of nano-technology, application in mulberry improvement.

PRACTICALS

1. Laboratory safety rules
2. Seri biotechnology lab and its facilities
3. Preparation of MS medium for tissue culture in mulberry
4. Selection, collection and preparation of plant material for mulberry tissue culture
5. Culturing of plant material/explant in culture media
6. Tissue culture techniques for mulberry propagation
7. Hardening of tissue cultured mulberry plants
8. Isolation of genomic DNA- mulberry leaf -I
9. Isolation of genomic DNA- mulberry leaf –II
10. Amplification of DNA in mulberry by using PCR
11. Study of diversity of mulberry germplasm by using molecular markers-I
12. Study of diversity of mulberry germplasm by using molecular markers-II

13. Comparative study of diversity of mulberry germplasm through morphological traits and molecular markers
14. Techniques for gene transformation in mulberry -I
15. Techniques for gene transformation in mulberry -II
16. Molecular databases in mulberry
17. Visit to MAS lab in Department of Biotechnology, UAS, GKVK, Bengaluru
18. Visit to Seri-Biotechnology Research Laboratory, CSB, Kodathi, Bengaluru

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading / Writing)
- Text books / Publication reviews
- Student presentations
- Group work
- Student's interview of key policy makers
- Case analysis and case studies and guest lectures
- Review of policy documents
- Visits

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- Burrell M. M., 1993, *Enzymes of Molecular Biology*. Humana Press Inc., NewYork. KENDREW, J., 1994, *The Encyclopedia of Molecular Biology*. Blackwell Scientific Publications, Oxford.
- Old R. W., Primrose S. B., 1994, *Principles of gene manipulation: An Introduction to genetic engineering*, 5th Ed. Blackwell Scientific Publications, U. S. A.
- Hansen, G. And Wright, M.S., 1999, Recent advances in the transformation of plants. *Trends in Biotech.*, **13**: 324-331.
- Vijayan, K., 2004, Genetic relationship of Japanese and Indian mulberry (*Morus* spp.) genotypes as revealed by DNA fingerprinting. *Plant Syst. Evol.*, **243**: 221-232.

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- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
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- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
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- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 507

Course Title: Anatomy and Physiology of Sericigenous insects

WHY THIS COURSE?

To understand the basic principles of anatomy, different organs/systems such as respiratory, circulatory, digestive, nervous and reproductive systems and their functional aspects (physiology) to strengthen the knowledge of students to take up meaningful research studies among sericigenous insects.

AIM OF THE COURSE:

This course is designed to provide basic information/knowledge on anatomy; internal organs/systems, functions and their (physiology) thorough understanding of the sericigenous insects. Silk production among various sericigenous insects, their evolution and differences will also be studied.

The course is organized as follows:

No	Blocks	Units
1.	Anatomy of sericigenous insects	1. Introduction, scope and importance 2. Anatomical studies of different systems 3. Comparison of anatomical structures among various sericigenous

2.	Physiology of different systems	<ol style="list-style-type: none"> 1. Introduction, scope and importance 2. Physiology of different systems 3. Silkworm nutrition and synthetic/artificial diets
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LEARNING OUTCOMES:

After successful completion of this course the students are expected to be able to –acquire basic knowledge about various systems in sericigenous insects, their structure and function. This will enable the students to thoroughly understand the nutritional requirements and silk production aspects. This will help the students to take up further research work meaningfully.

BLOCK 1: Anatomy of sericigenous insects

Unit 1: Introduction, scope and importance

Different structures of the various internal systems. The scope of the study for their application aspects and its importance for future research work.

Unit 2: Anatomical studies of various systems

Digestive, circulatory, respiratory, excretory, muscular, reproductive and nervous systems (including central, visceral and peripheral) and sense organs of larva, pupa and adult. Endocrine and exocrine glands (including silk glands).

Unit 3: Comparison of anatomical structures among various sericigenous insects:

Variation of anatomical structures in different life stages viz., larva, pupa and adult among different sericigenous insects mulberry, tasar, eri and muga.

BLOCK 2: Physiology of different systems

Unit 1: Introduction, scope and importance

Relation of structure to function and its application aspects.

Unit 2: Physiology of different systems

Physiology of digestive, circulatory, respiratory, excretory, muscular, reproductive, nervous system and endocrine and exocrine glandular systems, Hormonal mechanism, enzymes, pheromones, nutritional role of vitamins and other growth factors. Properties of haemolymph, histology, nerve impulses, sensory physiology. Silk glands and silk synthesis.

Unit 3: Silkworm nutrition and synthetic/artificial diets

Qualitative and quantitative nutritional requirement of silkworms, vitamins, carbohydrates, proteins and role of microbes in nutrition. Preparation of artificial/synthetic diets for silkworms. Endocrinal aspects of silk production.

PRACTICALS

1. Study of digestive system of mulberry silkworm and silk moth
2. Study of excretory system of mulberry silkworm and silk moth
3. Study of digestive system of larva of Eri silkworm
4. Study of nervous system and endocrine glandular system mulberry silkworm larvae & Eri silkworm larvae
5. Study of circulatory and reproductive system in mulberry silkworm
6. Study of circulatory and reproductive system in Eri silkworm
7. Study of silk glands in mulberry silkworm, tasar, Eri and muga silkworms
8. Study of properties of haemolymph of mulberry, Eri and tasar silkworms
9. Study of physiology of digestion and excretion of mulberry silkworm
10. Study of physiology of circulatory and nervous system of mulberry silkworm
11. Study of physiology of reproductive system of mulberry silkworm
12. Study of physiology of silk protein synthesis
13. Study of endocrine systems, diapauses and hibernation
14. Preparation of artificial diets/synthetic diets
15. Study of comparative anatomy of digestive system of pupa and adult of mulberry silkworm
16. Study of comparative anatomy of digestive system of pupa and adult of Eri silkworm
17. Detection of frequency of variation in vaorioles in eri moths resulting from larvae fed with different hosts
18. Visit to sericulture institutes

TEACHING METHODS / ACTIVITIES

- Lectures
- Dissections, drawing of sketches using camera lucida; grid / photograph of the system
- Text Books
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals
- Student presentations
- Assignments, practical record maintenance
- Preparation of artificial diets and their application.

RESOURCES

- Ather H. Siddiqi, 1982, *Experimental Physiology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- Beck, S.D., 1963, *Animal Photoperiodism*. Holt, Holt Library of Science Series, New York.
- Beck, S.D., 1980, *Insect Photoperiodism*. Academic Press, New York.
- Gilmour, D., 1961, *Biochemistry of Insects*. Academic Press, New York.

- Goldsmith, M.R. And František Marec, 2010, *Molecular Biology and Genetics of the Lepidoptera*. CRC Press Taylor & Francis Group, Broken Sound Parkway NW, USA.
- Govindan Bhaskaran, Stanley Friedman And Rodriguez, J.G., 1981, *Current Topics in Insect Endocrinology and Nutrition*. Plenum Press, New York and London.
- Morohoshi, S., 2000, *Development Physiology of Silkworms*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- Saxena, A.B., 1996, *Hormones of Insects*. Anmol Publications Pvt. Ltd., New Delhi.
- Sturnikov, V.A., 1976, *Control of Silkworm Development and Sex*. MIR Publishers, Moscow.
- Wigglesworth, V.B., 1956, *Insect Physiology*. 5th Edn., Rev. Methuen, London.

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- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Published by Department of Sericulture, Government of Karnataka, Bangalore.

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- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 508

Title: Silkworm Biochemistry and Nutrition

WHY THIS COURSE?

The silkworm growth directly depends on the food it consumes, digestion of consumed food to nutrients and assimilation of the digested nutrients into its body and then produce silk cocoons. The present course is designed to make the students understand the nutrients required for normal growth of silkworm and produce quality cocoons.

AIM OF THIS COURSE

The post graduate students should have a clear understanding of importance of feeding leaf with suitable nutrients in order to obtain reliable results of experiments conducted with silkworms. The course on silkworm biochemistry and nutrition will aim at enlightening the students on importance of raising silkworm on suitable mulberry leaves that nourish silkworm so as to undoubtedly infer the impact of treatments imposed during the experimentation. Further, they will be competent enough to emphasise on the balanced nutrition to mulberry among the farmers, since it's the sole food for silkworm.

The course is organized as follows:

No	Blocks	Units
1	Nutrients for silkworm growth	1. Requirement of nutrients to silkworm
		2. Metabolism and Utilization of nutrients
2	Biochemistry of nutrient utilization	1. Biochemical pathway for survival and cocoon production

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Understand the role and requirement of various nutrients in silkworm
- Learn the important biochemical pathways in silkworm that ultimately influence cocoon production

BLOCK 1: Nutrients for silkworm growth

Unit 1: Requirement of nutrients to silkworm

Carbohydrate, protein and fat metabolism, chemical nature of vitamins and hormones. Nutritional requirements of amino acids, lipids, vitamins, minerals. qualitative and quantitative requirements of nutrients.

Unit 2: Metabolism and Utilization of nutrients

Metabolism of amino acids, lipids, vitamins, minerals, Leaf composition as affecting silkworm growth, feed efficiency, supplementation of nutrients.

BLOCK 2: Biochemistry of nutrient utilization

Unit1: Biochemical pathway for survival and cocoon production

Physiology of moulting, egg and pupal diapause in silkworm, biochemical pathways of silk synthesis and biochemistry of haemolymph.

PRACTICALS

1. Qualitative tests for carbohydrates in silkworm haemolymph
2. Quantitative estimations of total soluble sugars in silkworm haemolymph
3. Qualitative tests for proteins and free amino acids in silkworm haemolymph
4. Quantitative estimations of proteins in silkworm haemolymph
5. Qualitative tests for lipids in silkworm haemolymph
6. Quantitative estimations of lipids in silkworm haemolymph
7. Determination of ascorbic acid level in the mulberry leaves
8. Determination of ascorbic acid level in silkworm haemolymph
9. Study of amylase activity in silkworm haemolymph
10. Study of phosphatase activity in silkworm haemolymph and digestive juice
11. Study of esterase activity in silkworm egg, larval haemolymph and silk glands
12. Qualitative tests for phospholipids and cholesterol in silkworm tissues
13. Quantitative estimation of phospholipids and cholesterol in silkworm tissues
14. Study of food consumption indices in silkworm
15. Estimation of lipid biomass in different silkworm breeds
16. Estimation of silk gland biomass in different silkworm breeds
17. Study of isozymes of different enzymes associated with silk productivity
18. Visit to Seri Bio-technology research laboratory/CSGRC

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

- Hamamura, Y., 2001, *Silkworm rearing on Artificial Diet*. Oxford & IBH Publishing Co. Pvt., New Delhi. P.287
- Reddy, D.N.R., Narayanaswamy, K.C., Manjunath Gowda And Jayaramaiah, M., 2005, *Morphology and Anatomy of Silkworms*. CVG Books, Bangalore. P.133.
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- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 513

Title: Biotechnology of Silkworm

WHY THIS COURSE?

Silkworm breeding by conventional methods takes relatively longer time. Combining different desirable traits in to one individual requires breaking linkage between desirable and undesirable traits. Application of biotechnology is essential to achieve early results in silkworm crop improvement.

AIM OF THIS COURSE

The course is aimed to provide knowledge on biotechnological methods and their application in silkworm crop improvement. The course will address the available methods and approaches that can be applied in the field of sericulture.

The course is organized as follows:

No	Blocks	Units
1	Biotechnological tools	1. Tissue culture techniques
		2. Biotechnological methods
2		1. Molecular characterization and mapping
	Application of biotechnology in silkworm	2. Transgenics, Bioinformatics and biosafety

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Understand the different biotechnological methods available in silkworm crop improvement
- Utilise methods and tools for evolving new silkworm breeds with desirable trait combinations

BLOCK 1: Biotechnological tools

Unit 1: Tissue culture techniques

Development of polyploids, gametoclonal variations - their scope and applications. Cryopreservation.

Unit 2: Biotechnological methods

Biotechnology and its scope in silkworm, recombinant DNA technology, genes transfer systems- vector mediated gene transfer, microinjection, electroporation, direct DNA uptake, gene gun technique, selectable markers and reporter system. Molecular markers.

BLOCK 2: Application of biotechnology in silkworm

Unit1: Molecular characterization and mapping

Mulberry silkworm germplasm characterization by using molecular markers, Development of maps, QTL mapping, MAS for economically important traits in silkworm, Mapping populations (F₂S and back crosses RILs, NILs, DHs), Molecular mapping and tagging of economically important traits.

Unit2: Transgenics, Bioinformatics and biosafety

Transgenic silkworm-prospects, achievements in silkworm. Silkworm as a bioreactor for foreign gene expression, Molecular aspects of silk synthesis. Application of biotechnological tools in

screening for biotic and abiotic stress resistance. Biosafety and regulatory issues, Intellectual Property Rights. Seri bioinformatics. Genomics-structural, functional and applications.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

K. P. Gopinathan, 1992, Biotechnology in sericulture, *Current Science*, 62(3) : 283-287.

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- www.tnau.ac.in/
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 516

Course title: Sericulture By-product utilization and Value addition

WHY THIS COURSE?

Sericulture generates a huge quantity of by-products at each stage of sericulture activity such as rearing bed waste, left over mulberry leaves, mulberry twigs, the discarded silk moth, waste egg sheets, pierced cocoons and damaged cocoons etc at grainage. And also inturn it possesses a vast entrepreneurship opportunities in silkworm rearing, silk reeling, re-reeling, twisting, winding, weaving etc. The present course is designed to make the students to understand all these opportunities in seri-by-products utilization and also entrepreneurship development thus making sericulture as one of the most profitable agro-enterprises.

AIM OF THIS COURSE

The course is designed with the aim of making the PG students to understand the best utilization of by-products generated at each stage of sericultural activity and their value addition for generating additional income making them good entrepreneurial managers in sericulture by exploring the vast entrepreneurial opportunities to make sericulture as one of the profitable enterprises for sustainable sericulture.

The course is organised as follows:

Sr.No.	Blocks	Units
1.	Entrepreneurship in sericulture	1. Entrepreneurship in sericulture and problems. 2. Sericultural entrepreneurship development in different countries.
2.	Entrepreneurship development in different stages	1. Entrepreneurship development during mulberry cultivation 2. Entrepreneurship development during egg production and silkworm rearing. 3. Entrepreneurship development during silk reeling and post reeling activities.

3.	Value addition of by-products in sericulture	<ol style="list-style-type: none"> 1. Value addition during host plant cultivation 2. Value addition during silkworm rearing 3. Value addition during silk reeling and post reeling.
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LEARNING OUTCOMES

After successful completion of this course, the students are expected be able to:

- Understand the entrepreneurship opportunities in sericulture and their problems during different stages of sericulture entrepreneurship
- Importance of value addition and utilization of sericultural by-products in agriculture and allied sectors.
- Non-textile opportunities for seri by-products and their value added products

BLOCK 1: Entrepreneurship in sericulture

Unit 1: Entrepreneurship in sericulture and problems

Concept, need, scope, prospects and problems of entrepreneurship in sericulture.

Unit 2: Sericultural entrepreneurship development in different countries

Sericultural entrepreneurial development in India, China, Japan and other sericultural countries.

BLOCK 2: Entrepreneurship development in different stages

Unit 1: Entrepreneurship development during mulberry cultivation

Entrepreneurship development in mulberry cultivation- kisan nursery, composting, vermicomposting, bio-digester, bio gas production, livestock production, fisheries, mushroom cultivation.

Unit 2: Entrepreneurship development during egg production and silkworm rearing

Entrepreneurial development in silkworm-egg production, Chawki rearing centres and cocoon production.

Unit 3: Entrepreneurship development during silk reeling and post reeling activities

Entrepreneurship development in silk reeling - establishment of reeling units, twisting and dyeing units, weaving units. Entrepreneurship development in manufacture/production, marketing/hiring of sericulture material/equipments and sericulture inputs.

BLOCK 3: Value addition of by-products in sericulture

Unit 1: Value addition during host plant cultivation

Value addition during host plant cultivation - mulberry as fuel, green manure, fodder, live fencing material, wind breaks. Mulberry fruits and uses in pickle, jam, jelly, beverage/wine preparation. Mulberry as medicine, mulberry in agriculture and sports industry, mulberry in biogas production, mulberry as shade and avenue tree. Processing of mulberry leaves for tea preparation and food products. Medicinal value of mulberry.

Unit 2: Value addition during silkworm rearing

Value addition during silkworm rearing –silkworm litter as livestock feed; as an organic manure, raw material for biogas production, mushroom raising, poultry feed, fish feed, silkworm excreta in cosmetic industry. Silkworm in human consumption.

Unit 3: Value addition during silk reeling and post reeling

Pupal oil extraction and its uses, pupal powder as animal feed and manure. Flimsy cocoons and waste cocoons used as raw material in spun silk industry and quilting purpose. Silkworm pupa in human consumption-commercialized products and locally prepared dishes. Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc., from waste cocoons. Sericin for medicine, cosmetics, artificial membranes and plastic industry and other uses of silk.

PRACTICALS

1. Visit to grainage for collection of waste cocoons including pierced cocoons
2. Visit to Chawki rearing centres and cocoon production centres for collection of different by-products
3. Visit to Silk reeling units, twisting, dyeing and weaving units for collection of different by-products
4. Preparation of compost, vermi-compost and biodigester from mulberry waste
5. Value addition during host plant cultivation-mulberry as fuel, green manure, fodder, live fencing material, wind breaks.
6. Estimation of calorific value of mulberry wood as fuel
7. Mulberry fruits for table purpose and preparation of pickles, juice, jam, jelly, beverage/wine
8. Raising of mulberry saplings from desired genotypes for social forestry, avenue tree and eco-friendly flora

9. Processing of mulberry leaf for the tea preparation
10. Preparation of different food products with mulberry leaf as ingredient
11. Mushroom cultivation using silkworm litter as substrate
12. Value addition during silkworm rearing – silkworm litter as cattle, sheep and goat feed
13. Preparation of mulberry silage along with popular fodders
14. Quantification of biogas production using silkworm waste
15. Pupal oil extraction and pupal powder preparation and nutrient status estimation
16. Preparation of handicrafts, toys, wall plates, garlands, greeting cards,
etc. using waste cocoons
17. Estimation of manurial value of compost and vermi-compost
derived from mulberry waste
18. Using of silkworm pupae as animal, fishery and poultry feed

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals / Publication reviews
- Study visits

RESOURCES

- Anonymous., 2002, *Silk Weaving*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- Anonymous, 2002, *Colours from Nature – Silk Dyeing Using Natural Dyes*. Vol. I and II, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- Bernard, P. Corbman., 1983, *Textiles: Fiber to Fabric*. 6th Edition, Mc. Graw – Hill International Editions, Home Economic Series, Singapore, p. 594.
- Charles, J. Huber., 1929, *The Raw Silk Industry of Japan*. The Silk Association of America, Inc., New York.
- Dandin, S.B. And Gupta, V.P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
- Dandin, S.B., Jayant Jayaswal. And Giridhar, K. (Eds.), 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore.
- Datta, R.K., 1996, Global Silk Scenario – 2001. Proceedings of the International Conference on Sericulture – 1994. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

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D.N.R., 2000, Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension. Vol. 3– Proceedings of NSTS – 1999, UAS, Bangalore.

Sanjay Sinha., 1990, *The Development of Indian Silk*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

Tazima, Y., 1978, *The Silkworm: An Important Laboratory Tool*. Kodansha Ltd., Tokyo. Tripurari Sharan., 1984, *Sericulture and Silk Industry*. Published by Y.K. Sharma, Consortium on Rural Technology, Delhi.

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COURSES FOR Ph. D (Agri.) IN SERICULTURE

COURSE CODE	COURSE TITLE	CREDITS
Major courses		
SER 601	Genetics and Breeding of Mulberry - II	1+1
SER 602	Physiology and Nutrition of Mulberry	1+1
SER 604	Physiological and Biochemical Genetics of silkworm	1+1
SER 605	Silkworm Pathology	1+1
SER 606	Integrated Pest Management in Sericulture	1+1
	Research and publications ethics	1+1
		6+6 =12
Minor courses *		
SER 603	Physiology and Nutrition of silkworm	1+1
SER 607	Sericulture Biotechnology	1+1
SER 608	Silk Technology -II	1+1
SER 609	Seri-Business Management	1+1
		4+4 =8
Supporting courses		
1	Plant Bio Security and Biosafety	1+ 0
2	Intlectual Property Rights and Regulatory	1+ 0
3	Climate Change and Sericulture	1+ 0
4	Organic Sericulture farming	1+1
		4+1 = 05

***Note: The students may opt the optional courses from any disciplines / departments as recommended by the advisory committee of the student based on the research top**

Credits: 1+1

Course Code: SER 601

Course title: Genetics and Breeding of Mulberry- II

WHY THIS COURSE?

In order to develop high yielding mulberry varieties for different situations, genetic principles and different advanced breeding methods are highly essential. In order to improve mulberry genetically, use of suitable germplasm and conventional methods and non-conventional methods of breeding are useful to meet the current needs. Hence this course.

AIM OF THE COURSE:

To make the students to get acquainted with advances in genetics, Cytogenetics and advanced breeding methods for mulberry improvement.

This course is organised as follows:

Sl. no	Blocks	Units
1	Origin and distribution of mulberry, germplasm and biometrical techniques	<ol style="list-style-type: none"> 1. Origin and exploitation of the genus <i>Morus</i> 2. Conservation and maintenance of mulberry germplasm 3. Biometrical Techniques in Breeding
2	Conventional and non-conventional breeding methods for mulberry improvement	<ol style="list-style-type: none"> 1. Conventional methods of mulberry breeding 2. Non- conventional methods of breeding 3. Biotechnological approaches for mulberry improvement

LEARNING OUTCOMES:

After successful completion of this course the students are expected to

- Know the importance of maintenance of indigenous and exotic lines of mulberry germplasm and their best exploitation in elite mulberry breeding
- Have Knowledge on different methods of breeding technology of mulberry for practical utilization
- Acquire knowledge on breeding of mulberry for various uses viz., young silkworm rearing, late age silkworm rearing, production of mulberry fruits and raising of tree mulberry.

BLOCK 1: Origin and distribution of mulberry, germplasm and biometrical techniques

Unit 1: Origin and exploitation of the genus *Morus*

Origin and exploitation of the genus *Morus*. Species of mulberry and their distribution. Wild species and local genotypes and their importance. A critical appraisal of taxonomy of genus *Morus*. Mode of reproduction in relation to breeding methods in mulberry and genetic constitution. Recent advances in cytology of mulberry. Karyomorphological studies, mitotic and meiotic studies. Recent advances in embryological studies. Study of different ploidy levels of mulberry.

Unit 2: Conservation and maintenance of mulberry germplasm.

Different types mulberry conservation. Role of mulberry germplasm in mulberry improvement. Characterization and evaluation of mulberry germplasm for morphological, anatomical, physiological, reproductive, biochemical and molecular traits. Evaluation of commercially released varieties/genotypes for different growth and yield parameters. Utilization of mulberry gene bank. National and international institutes involved in mulberry germplasm conservation.

Unit 3: Biometrical Techniques in Breeding

Introduction, Assessment of variability: simple measures of variability, Components of variance -Genetic diversity. Aids of selection: Correlation coefficient analysis, Path analysis-Discriminant function. Choice of Parents and Breeding procedures: Partial diallel analysis, Line x Tester analysis - Biparental cross analysis. Varietal adaptation: Components of adaptability, Assessment of stability.

BLOCK 2: Conventional and non-conventional breeding methods for mulberry improvement

Unit 1: Conventional methods of mulberry breeding

Procedures followed for different methods of conventional breeding- Introduction, mass selection and clonal selection. Handling of segregating progenies-pedigree selection and back cross method of selection. Exploitation of heterosis, different kinds of heterosis, estimation of heterosis in mulberry. Three tier system of evaluation of mulberry. Advances in conventional methods of breeding. Poly cross hybrids – Principles involved, advantages and disadvantages. Steps in development of polycross hybrids. Advanced generation breeding. Preliminary yield evaluation, multilocational trial and mulberry authorization for evaluation. Steps for orderly distribution of improved varieties. Release of new varieties. Multiplication system and distribution- Kisan nursery-important varieties developed in conventional method.

Unit 2. Non- conventional methods of breeding

Present status of mulberry varietal improvement through mutation. Importance of induced mutation, recent achievements in mulberry mutation breeding. Limitations of mutation breeding.

Polyploidy, induction of polyploidy in mulberry, special features of triploids in mulberry, process of triploid mulberry development, varieties developed by polyploidy breeding in mulberry. Breeding methods followed for leaf quality parameters, biotic and abiotic stress. Breeding strategies for climate change. Participatory plant breeding (PPB) – introduction, types, stages of participation, objectives, advantages of PPB, role of farmers in PPB.

Unit 3: Biotechnological approaches for mulberry improvement

Recent advances in application of plant tissue culture. Applications of molecular markers in mulberry improvement. Genome characterization. Development of transgenic mulberry – procedure.

Nanotechnology: introduction, main features and its applications. Plant Variety Protection Act (PVPA) – Introduction, types of protection, basic requirements, organizations, procedure, material to be protected, types of varieties, exemptions under PVPA, advantages and disadvantages of PVPA.

Statistical approaches for yield tests in mulberry: Field plot techniques in mulberry breeding experiments. Different experimental designs-RCBD, Augmented Randomized Complete Block Design (ARCB) and LSD.

PRACTICALS

1. Geographic distribution of the genus *Morus*, using maps
2. Evaluation of mulberry germplasm maintained at the Department of Sericulture, UAS, GKVK, Bengaluru
3. Study of diversity of mulberry germplasm maintained at the Department of Sericulture, UAS, GKVK, Bengaluru
4. Collection and categorization of available mulberry germplasm using standard key
5. Studies on conservation and maintenance of mulberry Gene bank
6. Identification of suitable mulberry genotypes for tree mulberry
7. Characterization of suitable mulberry genotypes and quality parameters for chawki silkworm
8. Characterization of suitable mulberry genotypes and quality parameters for late age silkworm
9. Identification of suitable mulberry genotypes for fruit purpose
10. Evaluation of commercially released mulberry varieties for growth and yield parameters
11. Phenotypic evaluation of commercially released mulberry varieties

12. Hands on training in callusing, sub-culturing, root initiation, shoot initiation and hardening of tissue culture plants, Triploids etc.
13. Active bud treatment for polyploid induction in mulberry
14. Layout of field experiments in mulberry
15. Testing for resistance to biotic stresses
16. Testing for resistance to abiotic stresses
17. Selective breeding using marker assisted selection for identifying WUE mulberry genotypes.
18. Visit to CSGRC Hosur / CSB

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

Chakraborti, S.P., Roy Chowdhuri, S. And Bindroo, B. B., 2013, *A text book on mulberry breeding and genetics*. Kalyani publications, New Delhi.

Amitabha Sarkar, *Mulberry breeding*. Kalyani publication, New Delhi.

Jalaja, K. S. And Ram Rao, D. M., 2008, Characterization of seven mulberry genotypes for their leaf quality and bioassay with silkworm, *Bombyx mori* L. *Sericologia*, **48**(1):85-93.

Das, B. C. And Krishnaswami, S., 1969, Estimation of components of variation of leaf yield and its traits in mulberry. *J. Seric.*, **9**(1): 26-30.

Sarkar, A., Chatterjee K. K. And Das, B. C., 1988, An easy and dependable method for strain selection in mulberry. *Sericologia*, **28**(2): 233-235.

Dandin, S.B., 1986, Mulberry breeding for tropics, In "*Lectures on Sericulture*". *Suriamya Publishers*, Bangalore, pp. 25-28.

B.D. Singh, *Plant breeding Principles and methods*.

JOURNALS

- *Indian journal of Sericulture*, Central Silk Board, Bangalore

- *Indian silk*, Central Silk Board, Bangalore
- *Seridoc*, Central Silk Board, Bangalore
- *Journal of sericultural science Japan*, Japan
- *Korean Journal of sericultural sciences*
- *Sericologia*, International Sericultural Commission, India.
- *Bulletin of Indian Academy of sericulture*.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in
- www.csrtimys.res.in/

Credits: 1+1

Course code: SER 602

Course Title: Physiology and Nutrition of Mulberry

WHY THIS COURSE?

Mulberry is a deep-rooted crop, draws its nourishment from different layers of the soil. Soil is the store house of water and nutrients which balances the vegetative and physiological growth. The physiological growth is more influenced by photosynthetic capacity, water transport system, absorption pattern of nutrients and carbohydrate metabolism in mulberry. Thus, having knowledge on the above vegetative and physiological growth will certainly help the students to acquire technical competency on above aspects. Hence this course.

AIM OF THE COURSE

The main aim of this course is to provide both physiological and nutritional management through different metabolism. Further, it also helps in understanding different nutritional requirement for different growth stages which is required for silkworm growth and development. In addition, the factors affecting absorption of nutrients and water, pathway of minerals, transpiration, photosynthesis, C4 pathway, cellular respiration, biotic and abiotic stress operating in mulberry will also be learnt. The principles of above and factors influencing them enhance the quality parameters of mulberry which is the need of the hour. The beneficial effect of all the mechanisms help to understand the phenology of mulberry. The academic knowledge on the above help in strengthening the skill of the students to serve the farming community effectively who are involved in quality leaf production and success of sericulture.

This course is organised as follows

Sl.No.	Blocks	Units
1	Mulberry Physiology	1. Factors affecting sprouting and establishment of cuttings, role of aeroponics. 2. Role of hormones in bud sprouting and rooting of cuttings
2	Growth and development of mulberry	1. Vegetative growth and development of mulberry
3	Plant growth hormones	1. Plant growth hormones and growth regulators
4	Photoperiodism and thermoperiodism	1. Photosynthesis in mulberry. 2. Respiration in mulberry
5	Water and nutrient absorption mechanism	1. Soil properties, nutrient uptake and growth of mulberry 2. Soil fertility and INM in mulberry 3. Role of water in mulberry physiology
6	Dormancy, abiotic and biotic stress in mulberry	1. Dormancy in mulberry buds and seeds 2. Biotic and abiotic stress in mulberry
7	Nutrient deficiency symptoms	1. Deficiency symptoms of major nutrients 2. Deficiency symptoms of secondary and micro nutrients

LEARNING OUTCOMES:

After successful completion of this course the students are expected to

- Acquire more information on both physiology and agronomic practices to be adopted in rain fed and irrigated mulberry garden.
- The student can utilize better techniques developed for both manure and fertilizer application.
- To gain understanding of different pathways of mulberry which will be helpful for water and nutrient management.

BLOCK 1: Mulberry Physiology

Unit 1: Factors affecting sprouting and establishment of cuttings, role of aeroponics.

Factors affecting sprouting and establishment of cuttings, Effect of temperature, cold, frost, light and salt. Aeroponics in mulberry. Possibility of deploying aeroponics in rooting and establishment of mulberry.

Unit 2: Role of hormones in bud sprouting and rooting of cuttings

Role of hormones in bud sprouting and rooting of cuttings and other physical agents like temperature, RH, light and water.

BLOCK 2: Growth and development of mulberry**Unit 1: Vegetative growth and development of mulberry**

Duration of vegetative period, leaf area development, phases of development in different age groups of plants (Bush and tree type).

BLOCK 3: Plant growth hormones**Unit 1: Plant growth hormones and growth regulators**

Plant growth hormones and growth regulators, classification, nature and biosynthesis in different aged plants and their functions.

BLOCK 4: Photoperiodism and thermoperiodism**Unit 1: Photosynthesis in mulberry**

Photosynthesis in mulberry. Factors affecting photosynthesis, light and dark reaction, stages of photosynthesis, Calvin cycle, C-4 pathway and productivity.

Unit 2: Respiration in mulberry

Respiration – Cellular respiration, glycolysis, fermentation, citric acid cycle. Transpiration –role of environmental factors affecting transpiration, role of flowering, fruit set and seed development.

BLOCK 5: Water and nutrient absorption mechanism**Unit 1: Soil properties, nutrient uptake and growth of mulberry**

Role of physical and chemical properties of soil on nutrient uptake and growth. Absorption pattern of major and micro nutrients in different soils.

Unit 2: Soil fertility and INM in mulberry

Response of mulberry varieties on absorption pattern of N, P, K and micronutrients. Status of various nutrients and soil fertility status and INM principles.

Unit 3: Role of water in mulberry physiology

Functions of water ecophysiology of plant, absorption of water, Passive absorption and Active absorption, pathway of minerals, root pressure.

BLOCK 6: Dormancy, abiotic and biotic stress in mulberry**Unit 1: Dormancy in mulberry buds and seeds**

Viability of buds and seeds, concept of plant stress, biotic and abiotic stress, water deficit stress on mulberry,

Unit 2: Biotic and abiotic stress in mulberry

Effect of temperature, cold, frost, light and salt on mulberry growth and development.

BLOCK 7: Nutrient deficiency symptoms**Unit 1: Deficiency symptoms of major nutrients**

Deficiency symptoms of N, P and K, toxicity of these nutrients in mulberry plants and their effect on quality of mulberry, reclamation of the soils by soil application, foliar application and fertigation methods.

Unit 2: Deficiency symptoms of secondary and micro nutrients

Key deficiency symptoms of S, Mn, Fe, Mo, Mg, Ca, Zn and other micronutrients and toxicity of these nutrients in mulberry plants and their effect on quality of mulberry, reclamation by soil and foliar application and fertigation methods.

PRACTICALS

- 1) Study of sprouting and rooting in different varieties of mulberry.
- 2) Use of different concentrations of plant growth hormones for establishment of mulberry
- 3) Study of root parameters in establishment of mulberry
- 4) Study of transpiration and photosynthesis in mulberry.
- 5) Study of leaf area measurement of different varieties of mulberry.
- 6) Study of different nutrients and their effect on growth and development of mulberry
- 7) Study of deficiency symptoms of NPK in mulberry
- 8) Study of mulberry seed viability tests.
- 9) Study of biochemical and mineral composition of leading mulberry varieties.
- 10) Study of absorption patterns of different fertilizers in mulberry
- 11) Study of different deficiency symptoms in mulberry.
- 12) Study of respiration in mulberry.
- 13) Evaluation of popular mulberry genotypes for biotic and abiotic stresses

- 14) Effect of various proportions of soil amendments on growth and development of mulberry
- 15) Study of deficiency symptoms of secondary and micro nutrients in mulberry through pot culture
- 16) Study of aeroponics in mulberry
- 17) Visit to aeroponic units at Department of Crop Physiology, UAS, GKVK, Bengaluru
- 18) Visit to NCBS laboratories, GKVK, Bengaluru

TEACHING METHODS AND ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES:

- Bongale, U.D.,2003, Nutritional Management and quality improvement in sericulture, *Proceedings of the National seminar on mulberry sericulture research in India* (26 th to 28th November 2001), P-1037
- Dandin, S.B. And Giridhar, K,2014, *Handbook of sericulture technologies*, CSB, Bengaluru, P-427
- Ganga, G., 2003, *Comprehensive Sericulture. Volume 2. Silkworm Rearing and Silk Reeling.* Oxford & IBH, New Delhi, P.429.
- Rajanna. L., Das, P.K.,Ravindran,S.,Bhogesha, K., Mishra,R.K., Singhvi, N. R., Katiyar, R. S. And Jayaram, H.,2005, *Mulberry cultivation and physiology*, Central Silk Board, Bangalore, P-367.
- Rangaswamy , G. Narasimhanna, M. N., Kasiviswanathan, K. And Sastry, C. R.1976, *Manual on Sericulture-I.Mulberry cultivation*, FAO, Rome, P.150
- Nutritional Management and Quality improvement in sericulture, 2003, KSSRDI. Bangalore.
- Zheng Ting-Zing, Tan Yun-Fang, Huang Guang-Xian, Fan Huaizhong And Ma Ben, *Mulberry cultivation.* Oxford & IBH publishing Co. pvt. Ltd., New delhi, Bombay and Calcutta.
- Ninge Gowda, K. N., *Morphology of mulberry.* Bangalore university, Jnanabharathi, Bengaluru
- Kichisaburo Minamizawa, Moriculture- Science of mulberry cultivation*

JOURNALS

- *Indian journal of Sericulture*, Central Silk Board, Bangalore
- *Indian silk*, Central Silk Board, Bangalore
- *Seridoc*, Central Silk Board, Bangalore
- *Journal of sericultural science Japan*, Japan
- *Korean Journal of sericultural sciences*
- *Sericologia*, International Sericultural Commission, India.
- *Bulletin of Indian Academy of sericulture*.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 604

Course Title: Physiological and Biochemical Genetics of Silkworm

WHY THIS COURSE?

Silk production is affected by both the environment and the genetic background of silkworm. The development of silkworm during its larval stage is crucial in obtaining quality cocoon yield. Understanding the genetic mechanism involved in various physiological and biochemical traits, which in turn influences the cocoon yield is essential in planning silkworm breeding strategies.

AIM OF THIS COURSE

The course is designed to make the students realize that silkworm development is influenced by the various physiological processes which are in turn governed by specific genes. Finally the student learns the relationship between these processes, the biochemical pathways and the genes that influence these processes and pathways.

The course is organized as follows:

No	Blocks	Units
1	Developmental Genetics	1. Embryonic development
		2. Post-embryonic development
2	Physiological genetics	1. Genetics of Physiology in silkworm
		2. Biochemical genetics in silkworm

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Appreciate the genetic background that influences the development of silkworm by governing the physiological and biochemical processes.
- Learn the mode of action of silkworm of decisive genes that are critical in silkworm development

BLOCK 1: Developmental Genetics Unit 1: Embryonic development

Embryonic development of non-hibernating and hibernating eggs; parthenogenesis; development of embryos under special genetic conditions, i.e., controlled by E- group allele, NC gene, NI-gene.

Unit 2: Post-embryonic development

Induction and translocation of quantitative and qualitative traits in silkworm. Quantitative traits affected by maturity genes, influence of environmental conditions on the expression of quantitative characters. Inheritance of moultnism, voltinsim and juvenility.

BLOCK 2: Physiological genetics

Unit 1: Genetics of Physiology in silkworm

Genetic control of hormonal mechanism. Role of voltinism genes on determination of quantitative characters. Maternal inheritance and its biochemical aspects. Genetic analysis of cocoon colours; physiology of pigments, genetic relation in terms of pigment permeability and transmission.

Unit 2: Biochemical genetics in silkworm

Genetic basis of enzymes – amylase – esterase – alkaline phosphatase – acid phosphatase –proteins and blood cells – haemocytes – ultrastructure of silkprotein synthesis – glutinous protein of the mucous gland. Importance of developmental, physiological and biochemical genetics in silkworm management, nutrition and breeding.

PRACTICALS

1. Silkworm embryo testing and preparation of slides
2. Embryonic development in non – diapausing eggs
3. Embryonic development in diapausing eggs
4. Linkage maps and regional differentiation of the chromosomes
5. Induction of parthenogenesis in silkworm, *Bombyx mori* L.
6. Maternal inheritance in mulberry silkworm
7. Inheritance of voltinism and moultinism in silkworm
8. Maternal inheritance and biochemical aspects
9. Genetics of cocoon colours in *Bombyx mori* L.
10. Sex determination in mulberry silkworm
11. e – group alleles as a tool of developmental genetics
12. Silkworm nutrition in relation to breeding
13. Preparation of artificial diets for mulberry silkworm, *Bombyx mori* L.
14. Biochemical genetics: genetic basis of enzymes
15. Estimation of amylase activity in different races of silkworm
16. Determination of nad-dependent sorbitol dehydrogenase activity in the diapausing eggs of *Bombyx mori* L.
17. Assessment of environmental influence on expression of quantitative traits
18. Study of induction of polyploidy in silkworm

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

- Anonymous, 1993, *Principles and Techniques of Silkworm Breeding*. ESCAP, UN, New York. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. P.111.
- Gardner, E.J., Simmons, M.J. And Snustad, D.P., 1991, *Principles of Genetics*, John Willey & Sons Inc., New York. P. 649.
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- Silks*. FAO - Agricultural Service Bulletin, Rome. P. 178.
- Kovalev, P.A., 1970, *Silkworm Breeding Stocks*. Central Silk Board, Bombay. P. 233.
- Sarker, D.D., 1998, *The Silkworm Biology, Genetics and Breeding*. Vikas Publishing House Pvt. Ltd., New Delhi. P. 338.
- Sarin, C., 1990, *Genetics*. Tata McGraw – Hill Publishing Co. Ltd., New Delhi. P. 528.
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- Sreeramareddy, G., 1998, *Silkworm Breeding*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. P.
- Tazima, Y., 1964, *The Genetics of Silkworm*. Logos Press Ltd., London. P. 253.
- Tazima, Y., 1978, *The Silkworm: An Important Laboratory Tool*. Kodansha Ltd., Tokyo, Japan. P. 307.

JOURNALS

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- *Indian silk*, Central Silk Board, Bangalore
- *Seridoc*, Central Silk Board, Bangalore
- *Journal of sericultural science Japan*, Japan
- *Korean Journal of sericultural sciences*
- *Sericologia*, International Sericultural Commission, India.
- *Bulletin of Indian Academy of sericulture*.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrddi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in
- www.csrtimys.res.in/

Credits:1+1

Course Code: SER 605

Course Title: Silkworm Pathology

WHY THIS COURSE?

It is well-known that silkworm diseases are posing a threat in silk cocoon production thereby causing severe losses to the silkworm rearers. Silkworm diseases are estimated to cause

a loss of 20 to 40% cocoon production. In addition, the quality of the cocoons produced also gets deteriorated affecting the economy of the cocoon rearers. Thus having detailed knowledge on the silkworm diseases with regard to various aspects will certainly help to produce competent technical man power. Hence is this course.

AIM OF THIS COURSE

The course is structured to provide both basic and applied knowledge on the viral, bacterial, protozoan and fungal diseases of silkworm as well as their prevention and control procedures. The course aims to provide the students the knowledge to diagnose and identify the different infections, knowledge on the etiological agents, their interactions etc. This certainly helps the students to equip them with basic and applied information with respect to various pathogens and their prevention so that it helps them in strengthening their academic knowledge and also to serve the farming community effectively.

The course is organised as follows:

Sl. No	Blocks	Units
1.	Viral diseases of silkworm	1. Viral diseases of silkworm 2. Prevention & control of viral diseases of silkworm
2.	Bacterial diseases of silkworm	1. Importance of bacterial diseases of silkworm 2. Bacterial diseases-symptomatology, prevention and control
3.	Protozoan & fungal diseases of silkworm	1. Protozoan diseases, pathogens, symptomatology, prevention & control 2. Fungal diseases, pathogens, symptomatology, prevention and control

LEARNING OUTCOMES

After successful completion of this course the students are expected to be able to.

- Conduct survey for the diseases of silkworm, their diagnosis & identification
- Utilize the culturing and staining techniques for silkworm pathogens
- Prevention & control successfully the silkworm diseases so as to enable the farmers to successfully produce cocoon cros.

BLOCK 1: Viral diseases of silkworm

Unit 1: Virus diseases of silkworm

Introduction to silkworm virus diseases. Symptomatology and basic knowledge on them. Economic importance, classification of silkworm viruses. Symptomatology and diagnosis of viral infections of silkworm. Purification of viruses and serological techniques. Nature, size

and morphology of nuclear polyhedrosis virus, cytoplasmic polyhedrosis virus, infectious flacherie virus, denonucleosis virus.

Unit 2: Prevention & control of viral diseases of silkworms

Predisposing factors, disease cycle including replications, other hosts and spread of virus diseases. Interaction among silkworm viruses. Histopathology and pathophysiology of viral infections. Prevention and control.

BLOCK 2: Bacterial diseases of silkworm

Unit1: Importance of bacterial diseases of silkworm

Introduction, history and importance of Bacterial diseases of the silkworm. Mixed infections. Etiology of bacterial flacherie, morphology and chemistry, pathogenicity, route of infection, silkworm immunity and serological detection.

Unit2: Bacterial diseases- symptomatology, prevention and control.

Introduction, bacterial septicemia, bacterial diseases of digestive organs. History and importance of Bacterial toxicosis of the silkworm. Structure and chemistry, biosynthesis of protein and chemistry of crystal toxin, histopathology, pathophysiology, Prevention and control.

BLOCK 3: Protozoan & fungal diseases of silkworm

Unit1: Protozoan diseases, pathogens, symptomatology, prevention & control.

Introduction, history and importance of the pathogenic protozoans of silkworms. Biodiversity, isolation, purification, morphology and chemistry of pathogenic protozoans. Strains of Microsporidians infecting silkworm and their life-cycle. Symptoms at the various stages of the life cycle of silkworm, pathologies, routes of infection, alternative hosts, cross infectivity, survival and spread, detection, prevention and control.

Unit2: Fungal diseases, pathogens, symptomatology, prevention and control.

Introduction to fungal diseases, economic importance and classification of fungal diseases of silkworms, general morphology of Deuteromycetes. Life cycle of the different fungi pathogenic to silkworms-white, green, yellow, black and red muscardines and *Aspergillus* diseases. Pre-disposing factors, symptomatology, pathology (histopathology and pathophysiology), host range, host susceptibility, prevention and control.

PRACTICALS

- 1) Survey for viral and bacterial diseases of silkworm based on external symptoms
- 2) Survey for protozoan & fungal diseases of silkworm based on external symptoms
- 3) Isolation & purification of silkworm viral pathogens
- 4) Isolation & purification of silkworm bacterial pathogens

- 5) Staining techniques for silkworm viruses & bacteria
- 6) Identification of silkworm pathogens based on morphology
- 7) Infectivity techniques for silkworm diseases
- 8) Cross infectivity of mulberry lepidopteran pests to silkworm
- 9) Cross infectivity of pathogens of silkworm pathogens to mulberry lepidopteran pests
- 10) Purification of pebrine pathogens & hatching of spores
- 11) *In-vitro* evaluation of chemicals against protozoan & fungal pathogens of silkworm
- 12) *In vivo* evaluation of effective chemicals against protozoan & fungal pathogens
- 13) Life cycle studies of important bacterial and fungal pathogens of silkworm
- 14) Interactions among different silkworm pathogens in silkworm
- 15) Practising hygienic measures in silkworm rearing for prevention of silkworm diseases
- 16) Practising shoot rearing method with net method of bed cleaning for prevention of silkworm diseases
- 17) Application of bed disinfectants against different diseases of silkworm.
- 18) Application of room disinfectants to eliminate silkworm pathogens.
- 19) Visit to Silkworm Pathology laboratory of CSB & State Sericulture Institute.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Students' presentations
- Experimentation
- Group discussions
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

Anonymous, 1975, *Text Book of Tropical Sericulture*. JOCO, TOKYO, Japan, pp.540-547.

Aruga, H. And Tanada, Y., 1971, *The Cytoplasmic polyhedrosis virus of silkworm*. Univ. Tokyo press, Tokyo, p.234.

Devaiah, M.C. And Govindan, R. 1995 *Aspergillosis of silkworms*. Silkworm pathology Technical Bulletin no.1, UAS, Bangalore, p. 68.

Ganga, G., 2003, *Comprehensive Sericulture*. vol. 2. Oxford and ub.Co.Pvt.Ltd., New Delhi, p. 430.

Govindan, R., Narayanaswamy, T. K. And Devaiah, M.C., 1998. *Principles of Silkworm Pathology*. Seri Scientific Publishers, Bangalore, p.420.

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- *Bulletin of Indian Academy of sericulture*.

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- www.tnau.ac.in
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 606

Course Title: Integrated Pest Management in Sericulture

WHY THIS COURSE?

Suppression of Pests of mulberry and non-mulberry silkworm food plants as well as pests of silkworms by deploying the chemical pesticides is known to be non-environmental friendly and induces resistance among pests causing pest outbreaks. The same is deleterious for silkworms, thus resulting in cocoon crop losses. Hence, it is always advisable to make use

of the available methods of prevention and suppression methods in suitable combination i.e., integrated management of pests so as to keep their populations below the economic injury level for successful cocoon crop production. The above knowledge among Ph.D students is essential and hence this courses assumes importance.

AIM OF THIS COURSE

The course is structured to improve knowledge on pests, factors affecting their biotic potential, damage caused, bio-ecology and integrated managements of pests of mulberry and non-mulberry silkworm food plants and mulberry as well as non-mulberry silkworms. In addition,the eco-friendly management practices for these pests will also be taught.

The course is organised as under

Sl.No	Blocks	Units
1	Pest and pest outbreak	1. Pests, classification and Damage 2. Pest outbreaks and pest surveillance & forecasting
2.	Pest management	1. Principles and methods 2. Eco-friendly pest management
3.	Bio-ecology and management of pests	1. Mulberry pests 2. Mulberry silkworm uzifyly 3. Grainage pests 4. Pests of non-mulberry silkworm food plants 5. Pests of non-mulberry silkworms

LEARNING OUTCOMES:

After undergoing this course the students will acquire knowledge on the concept of pest, damage caused, outbreaks, pest management principles and methods, IPM and eco-friendly measures. In addition, they will have detailed information on the bio-ecology and management of pests encountered in sericulture which certainly helps them for effective advocation to the rearers and granears. This inturn ensures sustainability of sericulture.

BLOCK 1: PEST AND PEST OUTBREAK

Unit 1: Pests, classification and damage.

Concept of pests, classification of insect pests. Types of damage caused to host plants of silkworms and assessment of extent of damage.

Unit 2: Pest outbreaks and pest surveillance and forecasting

Causes for insects assuming pest status. Factors affecting the natural balance of insects in mulberry eco-system. Pest surveillance and forecasting of outbreaks.

BLOCK 2: PEST MANAGEMENT**Unit 1: Principles and methods concept of pest management.**

Principles and methods of pest management. Integrated pest management – Meaning, practical utilization and merits.

Unit 2: Eco-friendly pest management.

Eco-friendly pest management – concept, incorporation in IPM package, benefits. Development of cultural and mechanical methods, botanicals, other animal derived insecticides and biological control means in IPM.

Block 3: BIO – ECOLOGY AND INTEGRATED MANAGEMENT OF PESTS**Unit 1: Mulberry Pests**

Bio-ecology and IPM of root feeding, steam boring, leaf eating and sap sucking pests of mulberry.

Unit 2: Mulberry silkworm uzifly

Biology of mulberry silkworm uzifly in relation to the biotic and abiotic environment and IPM package for the pest.

Unit 3: Grainage pests

Pests encountered in mulberry silkworm egg production centres, damage caused and their management.

Unit 4: Pests of non-mulberry silkworm food plants.

Incidence and extent of damage caused by pests on castor, terminalia and som. Biology of important defoliators and effect of ecological factors and IPM of important pests.

Unit 5: Pests of non-mulberry silkworms.

An account of biology of pests and predators of tropical and temperate tasar silkworms and muga silkworm. Pests of eri silkworm. IPM of *Blepharipa zebra*, *Canthecona furcellata* and bird predators of tropical tasar.

PRACTICALS

1. Survey and collection of insect pests of mulberry and their classification
2. Observations on nature and extent of damage and loss occurred to mulberry
3. Sampling methods for pest surveillance

4. Incidence of termites on different varieties of mulberry
5. Incidence of jassids, black headed hairy caterpillar and leaf folder on mulberry
6. Incidence of white mealy bug on different mulberry varieties
7. Life cycle of black headed hairy caterpillar on mulberry & castor
8. Biology of mulberry leaf webber and its varietal preference & IPM
9. Study of botanical pesticides and bio-agents used in mulberry pest management
10. Study of biological control agents used in mulberry eco-system and uzifly management
11. Forms, formulations and application of pesticides
12. Safety insecticides, their permissible limits and safety periods in mulberry pest management
13. Integrated management of rootknot nematode of mulberry
14. Incidence and biology of uzifly on mulberry silkworm
15. Construction of life table for indian uzifly based on the available data
16. Integrated management of mulberry silkworm uzifly
17. Survey for insect and non-insect pests in mulberry silkworm grainage
18. Study of pests of castor and *Terminalia* spp. and their management
19. Visit to CSGRC, Hosur / R & D institutions

TEACHING METHODS / ACTIVITIES

- Lectures
- Providing study materials/lecture materials
- Practical manuals
- Assignments (writing/reading)
- Text books / publications/reviews/technical bulletins/manuals/proceedings of scientific seminars
- Students presentations
- Group discussions
- Visits to silkworm rearing house /silkworm pathology laboratories

RESOURCES

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- Dent, D.R. And Walton, M.P., 1997, *Methods in Ecological and Agricultural Entomology*. CAB International, Cambridge.
- Gautam, R.D., 1994, *Biological Pest Suppression*. Westvill Publishing House, New Delhi.
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- Govindan, R., Ramakrishna Naika And Sannappa, B., 2004, *Progress of Research on Disease and Pest Management in Sericulture*. Seri Scientific Publishers, Bangalore.
- Huang, E., 2003, *Protection of Mulberry Plants*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
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- *Journal of sericultural science Japan*, Japan
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- www.csrtimys.res.in/

Credit: 1+1

Course Code: SER 603

Course Title: Physiology and Nutrition of Silkworm

WHY THIS COURSE?

Present Sericulture and allied sectors face tremendous challenges on multiple points, quality silk production, disease management, nutritional and ecological security to silkworms. Researchers, stake holders are benefited with knowledge and skill so as to reduce the risks in silk production.

AIM OF THE COURSE:

The course is designed to provide both basic and applied knowledge to avoid risks in silkworm rearing. It aims to equip students to indentify, evaluate and evolve ways to address risks in silkworm rearing, quality silk production and to evolve artificial nutritional diets for silkworms.

The course is organized as follows:

No	Blocks	Units
1.	Importance & scope	1. Importance of physiology
	Physiological studies	1. Physiology of digestion and excretion 2. Physiology of circulation and respiration 3. Physiology of endocrine system, egg diapauses and its role in growth and development 4. Physiology of silk synthesis. 5. Nutrition of silkworms
2.	Applied aspect of physiological studies	1. Hormone and enzyme applications 2. Preparation of artificial diets for productivity of silk

LEARNING OUTCOMES:

After successful completion of this course the students are expected to be able to

- Understand the basic aspects of physiological studies to apply it for research work in P.G.
- Learning to establish skills and tools of physiological studies to apply on growth and development of silkworms & silk productivity.
- Utilize the knowledge for its application of entrepreneur development for production of products related to growth and development of silkworm and silk productivity and quality.

BLOCK 1: Importance and Scope

Unit 1:Importance of physiology

Study the importance, progress in developed countries Japan, China, Korea and the importance in India.

Unit 2. Scope and Development of Sericulture

Study the scope and development of physiological studies and its applications in sericulturally advanced countries

BLOCK 2: Physiological studies

Unit 1 Physiology of digestion and excretion

Physiology of digestion and excretion enzymes, metabolism and various nutrients carbohydrates, proteins amino acids, vitamins, minerals excretory physiology, water conservation and utilization in the body.

Unit 2. Physiology of circulation and respiration

Physiology of circulation and respiration. Haemolymph its composition various cells in haemolymph phagocytes, leucocytes, etc amylase, synthesis of blood role of enzymes and hormones on circulation. Physiology of respiration, O₂ supplementation, purification of haemolymph.

Unit 3. Physiology of endocrine system, egg diapauses and its role in growth and development

Physiology of endocrine system, Brain hormone, prothoracic gland hormone, corpora allata, corpora cardiac, sub-oesophageal glands, growth and development, moulting, diapauses pro synthesis of pheromones and their role in regulating silkworm behaviour. PTTH, JH analogues physiology of moulting and spinning.

Unit 4. Physiology of silk synthesis

Physiology of silk synthesis, Prio synthesis and fibroin sericin role of lyonet / pilippis gland, Molecular basis of silk protein synthesis, sericin and fibroin.

Unit 5. Nutrition of silkworms

Utilizing of mulberry leaves, nutritional requirements of silkworms, digestion and utilization of various nutrients digestive enzymes, metabolism of various kinds of nutrients, carbohydrates, proteins, amino acids, vitamins and minerals.

BLOCK 3: Applied aspect of physiological studies:

Unit 1. Hormone and enzyme applications

Hormone and enzyme application tricontinol, serimore, sampoorna JH analogues, moulting hormones.

Unit 2. Preparation of artificial diets for productivity of silk

Preparation of artificial clients for silk productivity. Diets with mulberry composition, diet without mulberry and classification of diets. Nutrient supplementation.

PRACTICALS

1. Study of consumption indices of carbohydrates utilization
2. Study of consumption indices of proteins and lipids utilization
3. Study of amylase activity in digestive juice of different breeds of silkworm
4. Study of esterase activity in egg, haemolymph and silk glands of different breeds of silkworm
5. Study of acid phosphatase activity in haemolymph and alkaline phosphatase digestive juice of different breeds of silkworm.
6. Determination of free amino acids in the haemolymph of silkworm
7. Determination of trehalose content in the haemolymph of silkworm
8. Application of hormones on growth and development of silkworms
9. Testing of plant products for growth and productivity in silkworm
10. Application of JH analogues and study its influence on growth and development of mulberry silkworm
11. Application of MH analogues and study of its influence on growth and development of mulberry silkworm
12. Determination of NAD-dependent sorbitol dehydrogenase activity during egg diapause
13. Nutrition supplementation through leaf fortification and its studies on growth and development.
14. Preparation of artificial diets with mulberry component
15. Preparation of artificial diets (synthetic) without mulberry components
16. Visit to CSTRI / NSSO
17. Visit to SERICARE / Crop Physiology lab
18. Visit to SRBL Kodathi, Karnataka

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

- Ather H. Siddiqi, 1982, *Experimental Physiology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- Beck, S.D., 1963, *Animal Photoperiodism*. Holt, Holt Library of Science Series, New York.
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- Butterworth And Henmann., 1993, *Analysis of Amino Acids, Proteins and Nucleic Acids*. Biotol Series
- Butterworth And Heinemann., 1993, *Cellular Interactions and Immunobiology*. Biotol Series
- Branden, C. And Tooze, J., 1991, *Introduction to Protein Structure*. Garland Publishing Inc., New York & London.
- Giese, A.C., 1973, *Cell Physiology*. 4th Edn., Philadelphia, Saunders. GILMOUR, D., 1961, *Biochemistry of Insects*. Academic Press, New York.
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- Govindan Bhaskaran, Stanley Friedman And Rodriguez, J.G., 1981, *Current Topics in Insect Endocrinology and Nutrition*. Plenum Press, New York and London.
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- www.tnau.ac.in
- www.csrtimys.res.in/

Credits:1+1

Course Code: SER 607

Course Title: Sericulture Biotechnology

WHY THIS COURSE?

Hybridization and selection in segregating progenies of mulberry are very difficult because of its heterozygosity. In order to aid the selection in mulberry, biotechnological tools viz., Tissue culture techniques, molecular markers and recombinant DNA technology are more useful to aid in selection. Application of these techniques will shorten the breeding procedure. Hence this course.

AIM OF THIS COURSE:

The course is designed to equip the PG students with recent developments in the field of Tissue culture techniques, molecular markers, mapping and sequencing and recombinant DNA technologies applied both in mulberry and silkworm improvement.

The course is organised as follows:

No.	Blocks	Units
1	Biotechnology in Sericulture	1. Perspective, scope and current status of biotechnology in Sericulture
		2. Mapping and sequencing of mulberry and silkworm
2		1. Tissue culture in mulberry
3	Tissue culture and Recombinant DNA techniques	2. Recombinant DNA techniques in mulberry and silkworm
		3. Seri bioinformatics

LEARNING OUTCOMES

After successful completion of this course the students are expected to be able to

- Utilize the methods and tools of tissue culture and recombinant DNA technologies for mulberry and silkworm improvement.

BLOCK 1: Biotechnology in sericulture

Unit 1:Perspective, scope and current status of biotechnology in Sericulture

Perspective, scope and current status of biotechnology. Techniques adopted in Restricted Fragment Length Polymorphism (RFLP), Random Amplified Polymorphic DNA (RAPD),Amplified Fragment Length Polymorphism (AFLP)

and Simple Sequence Repeats (SSR). Applications of PCR (Polymerase chain reaction) and agarose gel electrophoresis.

Unit 2. Mapping and sequencing of mulberry and silkworm

Mapping and sequencing of mulberry and silkworm. Genome of mulberry and silkworm. Molecular basis for improvement of yield components in mulberry and silkworm.

BLOCK 2: Tissue culture and Recombinant DNA techniques

Unit 1: Tissue culture in mulberry

Micro propagation in mulberry, Production of haploids and Double haploids (DH) lines, Synthetic seeds, Induction of *in vitro* flowering, *In vitro* screening of mulberry for different stress conditions. Somaclonal and Gametoclinal variations - their scope and applications. Cryopreservation in mulberry for germplasm preservation. Protoplast culture and somatic hybridization.

Unit 2: Recombinant DNA techniques in mulberry and silkworm

Recombinant DNA techniques in mulberry and silkworm. Role of agents and microorganisms with emphasis to common vectors for gene transfer. Stability and expression of transferred genes in mulberry and silkworm. Germline transformation and scope of genetic manipulation between silkworm breeds. Application of molecular techniques in gene identification for

further breeding programmes. Application of site directed mutagenesis, gene targeting and gene therapy. Silk gland genetics.

Units 3. Seri bioinformatics

Seri bioinformatics- introduction, branches of bioinformatics, computer programmes used. application in crop improvement. Studies on Genomics- genomics in crop improvement, types of genomics: structural, functional and applications, achievements and limitations. Studies on proteomics, Metabolomics. Nano technology- introduction, main features, Application of nano technology in mulberry improvement.

PRACTICAL

1. RFLP marker technique as applied to mulberry crop
2. RFLP marker technique as applied to silkworm improvement programmes
3. RAPD marker technique as applied to mulberry crop
4. AFLP marker technique as applied to mulberry crop
5. SSR marker technique as applied to mulberry crop
6. Equipments and chemicals used in RFLP and RAPD techniques
7. Equipments and chemicals used in PCR technique

8. Hands on training in mulberry DNA extraction, isolation, purification and concentration
9. Hands on training in silkworm DNA extraction, isolation, purification and concentration
10. DNA quantification and quality assessment in mulberry
11. DNA quantification and quality assessment in silkworm
12. Procedure of Agarose gel electrophoresis
13. Application of PAGE in silkworm
14. PCR reaction; PCR amplification;
15. Estimation of genetics distances- cluster analysis in mulberry
16. Estimation of genetics distances- cluster analysis in silkworm
17. Visit to Seribiotech. Lab. of CSB at Kodathi
18. Visit to MAS lab and biotechnology lab of UAS (B)
19. Visit to CSR&TI, Mysore- biotechnology division

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books
- Student presentations
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals

RESOURCES

- BURRELL, M. M., 1993, *Enzymes of Molecular Biology*. Humana Press Inc., NewYork. SAMBROOK, J. AND RUSSEL, D. W., 2001, *Molecular cloning- A Laboratory Manual* 3rd Ed. Cold Spring Harbor Laboratory Press. Cold Spring Harbor, Newyork.
- SMITH, S. AND HELENTYARIS, T., DNA finger printing and plant variety production. Genome mapping in plant edited by Andrew H Paterson R G Lands Company.
- KENDREW, J., 1994, *The Encyclopedia of Molecular Biology*. Blackwell Scientific Publications, Oxford.
- OLD R. W. AND PRIMROSE S. B., 1994, *Principles of gene manipulation: An Introduction to genetic engineering*, 5th Ed. Blackwell Scientific Publications, U. S. A.
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- DANIELL, H., KHAN, M. S. AND ALLISON, L., 2002, Milestones in chloroplast genetic engineering: an environmentally friendly era in biotechnology. *Trends in Plant Science*, **7**: 84-91.
- CHICAS, A. AND MACINO, G., 2011, Characteristics of post transcriptional gene silencing. *Embo. Reports*, **21**: 992-996.
- KOOTER J. M., MATZKE, M. A. AND MEYER, P., 1999, Listening to the silent genes: transgene silencing, gene regulation and pathogen control. *Trends in Plant Science*, **4**: 304-307.
- AWASTHI, A. K., NAGARAJA, G. M., NAIK, G. V., KANGINAKUDRU, S.,
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- www.tnau.ac.in
- www.csrtimys.res.in/

Credits: 1+1

Course code: SER 608

Course Title: Silk Technology-II

WHY THIS COURSE?

Next to mulberry silk the other source of natural silk is from non-mulberry sector which is considered to be more profitable in India. Among four commercially exploited silkworm species Tasar, Muga and Eri are having vast diversity and uniqueness in silk quality which provide ancient customary rural employment and remunerative income to huge number of people mainly focusing on tribals. Information on this to students enlightens more on their distribution and characteristic features along with extraction of these silks. Hence this course attains importance.

AIM OF THE COURSE

Non-mulberry sericulture has a glorious heritage. India is the largest user of silk and ranks next to China in global production. Tasar silk industry in India provides rural employment and remunerative income to the tribal population because it requires least investment to get

high return. Non-mulberry sericulture has multi-tier earning potential to support rural enterprises/ entrepreneurs, especially in the area of silkworm seed production, commercial cocoon production, Yarn preparation and fabric making besides huge potentials in waste utilization. Therefore, greater emphasis and thrust should be laid on over all development of non-mulberry sericulture. The students after undergoing this course will have the benefit of all recent innovations in reeling technology of Tasar, Muga and spinning technology of Eri and their by-products that will throw light on present scenario of non-mulberry sericulture (Vanya silk) with present facts and figures.

This course is organised as follows

Sl. No.	Blocks	Units
1	Scope of non-mulberry sericulture	1. Introduction and spread of non-mulberry sericulture 2. Non-mulberry sericigenous insects
2	Commercially exploited non-mulberry silks	1. Physical characteristics – Eri, tasar and muga cocoons 2. Commercial characteristics- Eri, tasar and muga cocoons

3	Reeling technology for non-mulberry silk cocoons	1. Reeling technology for non-mulberry silk cocoons
4	Spinning of Eri silk cocoons and By-product utilization	1. Spinning of Eri silk cocoons 2. By-products of non-mulberry silk industry and their utilization
5	Economics of non-mulberry silk reeling unit establishments	1. Organization of non- mulberry silk reeling units
6	Conventional and non-conventional energy, health and environmental hazards	1. Use of conventional and non-conventional energy in silk Reeling industry 2. Health and environmental hazards in silk reeling

LEARNING OUTCOME:

After undergoing this course the students are exposed to recent reeling techniques adopted in extraction of all non-mulberry silks and the ill effects of reeling industry and it helps in managing both the effluents and smoke and their proper disposal for building up of eco-friendly environment.

BLOCK 1: Scope of non-mulberry sericulture

UNIT 1: Introduction and spread of non-mulberry sericulture

Introduction, spread of non-mulberry sericulture in world and India and its utility to tribal people.

Unit 2: Non-mulberry sericigenous insects

Different non-mulberry sericigenous insects - fagara silk, coan silk and anaphe silk.

BLOCK 2: Commercially exploited non-mulberry silks

Unit 1: Physical characteristics – Eri, tasar and muga cocoons

Cocoon colour, shape, size, compactness, peduncle and ring in respect of Eri, tasar, muga, anaphe, fagara and coan silk cocoons.

Unit 2: Commercial characteristics- Eri, tasar and muga cocoons

Cocoon weight, shell weight, shell percentage, filament length, denier, kakame, non-breakable filament length, reelability, raw silk percentage in respect of Eri, tasar, muga, anaphe, fagara and coan silk cocoons.

BLOCK 3: Reeling technology for non-mulberry silk cocoons**Unit 1: Reeling technology for non-mulberry silk cocoons**

Cocoon stifling and cooking methods, brusing, processing, wet and dry reeling of tasar and muga cocoons. Various equipments for reeling- Tevedi, N.R. Das, CTRS improved reeling machine for tasar cocoon reeling and Choudhari reeling machine for muga silk cocoons, drying and skein making. Semi-automatic reeling machine and Automatic Reeling Machine. Testing and grading of non-mulberry silks.

BLOCK 4: Spinning of Eri silk cocoons and By-product utilization**Unit 1: Spinning of Eri silk cocoons**

Definition of spun silk, Various steps involved in spun silk industry (processing, degumming, washing and drying), Eri cocoons as raw material for spun silk industry- spinning of eri cocoons, hand spinning using Natwa, Takli, machine spinning using Amber charaka, madleri charaka and finished products, characteristic features, production of spun silk from pierced tasar and muga cocoons on takli, bhir and N.R. Das spinning wheel.

Unit 2: By-products of non-mulberry silk industry and their utilization

Use of different types of tasar wastes, by-products of tasar reeling - gicha, katia and matka silks. Use of pierced cocoons of tasar and muga, cooking waste, reeling waste and pelade layer. Silk wastes, extraction of pupa oil and its use in various fields. Pupa oil mill.

BLOCK 5: Economics of non-mulberry silk reeling unit establishments**Unit 1: Organization of non- mulberry silk reeling units**

Organizational set up of reeling and spinning establishments for tasar, muga and Eri. Site for reeling, facilities for reeling and requirement of human skill and resources for reeling and

spinning. Calculation of quantity of cocoons for different reeling and spinning units based on the raw material required for the available appliances. Working out of economics of reeling taking into account the cost of production and returns from resultant raw silk in respect of tasar and muga. Economics of eri spinning.

BLOCK 6: Conventional and non- conventional energy, health and environmental hazards in silk reeling industry

Unit 1: Use of conventional and non-conventional energy in silk Reeling industry

Overview, energy / wood / fuel/power consumption in cocoon stifling, cooking and reeling-release of smoke, constituents of smoke – effect of smoke on human health and rearing

environment. Effluents from silk production. Solid waste, dust, smoke and effluents from silk weaving factory and spun silk mills.

Unit 2: Health and environmental hazards in silk reeling

Effect of reeling industry on ecosystem. Occupational health risk on reelers / workers – skin and lungs related problems in reeling units due to release of smoke. Constituents and effect of smoke on human health and environment. Effluents from silk production. Solid waste, dust, smoke and effluents from silk weaving factory and spun silk mills. Policies on pollution control programmes on health hazards – risk and proposed options.

PRACTICALS

1. Collection and preservation of non-mulberry silk cocoons in wild
2. Study of biodiversity of non-mulberry silk fauna on different hosts.
3. Study of marketing system of cocoon transaction of Tasar
4. Study of marketing system of cocoon transaction of Muga
5. Study of marketing system of cocoon transaction of Eri
6. Study of physical parameters of the Tropical Tasar and Muga cocoons
7. Study of physical parameters of the Eri cocoons
8. Study of physical parameters of Japanese, Chinese and temperate Tasar cocoons
9. Study of commercial parameters of different ecoraces of tropical tasar
10. Study of commercial parameters of Muga and Eri silk cocoons
11. Study of different methods of stifling for Tasar and Muga Cocoons
12. Study of different methods of cooking for Tasar and Muga Cocoons
13. Study of use of enzymes in Tasar cocoon cooking
14. Study of different reeling machinery for Tasar and Muga
15. Study of different spinning appliances for Eri cocoons
16. Visit to spun silk mill to get acquainted with steps of silk spinning
17. Visit to Central Silk Technological Research Institute, Bengaluru
18. Estimation of cost and returns of establishment of reeling units and spun silk unit

TEACHING METHODS AND ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books / Publications / Technical bulletins / Manuals / Scientific journals and periodicals
- Student presentations

- Experimentation
- Group discussions
- Group work
- Laboratory exercises

RESOURCES:

- BHASKAR, R. N. and GOVINDAN, R., 2005, *Techniques in Silk Reeling*, Department of Sericulture, UAS,GKVK,p-50.
- GANGA, G., 2003, *Comprehensive Sericulture. Volume 2. Silkworm Rearing and Silk Reeling*.Oxford & IBH, New Delhi, p.429.
- JOLLY,M.S., SEN, S. K., SONWALKAR, T. N. AND PRASAD, G. K.,1972, *Manual on Sericulture-IV.Non mulberry silks, FAO, Rome, p.178.*
- KAMAL JAISWAL, SUNIL P. TRIVEDI, PANDEY, B. N. AND TRIPATHI, A. K., *Mulberry sericulture-problems and prospects*, A P H publishing corporation, New Delhi-110 002.
- KIM, B. H.,1978, *Raw Silk Reeling*, Korean edition Seoul Publishing Company, p. 275
- MAHADEVAPPA, D., HALLIYAL, V. G., SHANKAR, A. G. AND RAVINDRA BHANDIWAD, *Mulberry silk reeling technology*, Oxford & IBH publishing Co. Pvt. Ltd. *Manual on Bivoltine silk Reeling Technology*, 2003, Published by JICA, PPP BST Project, p-122
- MOHANTY, P. K., Tropical tasar culture in India.
- SAVITHRI, SUJATHAMMA AND NEERAJA, *Sericulture industry: An overview*. Sri padmavathi mahila viswavidhyalayam, Tirupati, Andhra Pradesh.
- TRIPURARI SHARAN, *Sericulture and silk industry*, Consortium on rural technology, Madhuvan, Delhi- 110092.
- Vanya wild silks of India- An users compendium*, Vol.1 An Introduction to vanya silks, Central silk board, Banglore.

JOURNALS

- *Indian journal of Sericulture*, Central Silk Board, Bangalore
- *Indian silk*, Central Silk Board, Bangalore
- *Seridoc*, Central Silk Board, Bangalore
- *Journal of sericultural science Japan*, Japan
- *Korean Journal of sericultural sciences*
- *Sericologia*, International Sericultural Commission, India.
- *Bulletin of Indian Academy of sericulture*.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in
- www.csrtimys.res.in/

Credits: 1+1

Course Code: SER 609

Course title: Seri-Business Management

WHY THIS COURSE?

Sericulture industry possesses a vast opportunity for entrepreneurship at different stages of activities for rural and urban India inturn opening a huge business opportunities viz., raising saplings in nursery, Grainage, Chawki rearing centre, Silkworm rearing, silk reeling, re-reeling, twisting, doubling and weaving fabric. The present course is designed to make the students to understand the vast entrepreneurship and business management opportunities and risk and non-cash input management associated in sericulture.

AIM OF THIS COURSE

The students will know and understand the business opportunities and their management in various activities of sericulture, their constraints, risk management etc.

The course is organised as follows:

Sr.No.	Blocks	Units
1.	Silkworm seed production management	1. Sericulture industry-An overview. 2. Management of silkworm seed production and the associated resources
2.	Leaf production and silkworm rearing programme management	1. Leaf production and supply management, 2. Synchronized silkworm rearing programme management
3.	Silk reeling unit management	1. Management of reeling unit 2. Constraints and risk management

LEARNING OUTCOMES

After successful completion of this course, the students are expected to be able to:

- Understand the Business opportunities in sericulture and their constraints and risk management during different activities of sericulture that helps for earning their livelihood.

BLOCK 1: Silkworm seed production management

Unit 1: Sericulture industry-An overview.

Sericulture industry – overview, concept and principles of management, personal and resource management.

Unit 2: Management of silkworm seed production and the associated resources

Silkworm seed production management – organizational set up, selection of site, ground plan and establishment of grainage, production planning, raw material, manpower, seed storage programme, marketing, record maintenance; case studies.

BLOCK 2: Leaf production and silkworm rearing programme management

Unit 1: Leaf production and supply management

Quality mulberry leaf production and supply management

Unit 2: Synchronized silkworm rearing programme management

Synchronized silkworm rearing programme – manpower, community rearing, house management, marketing of cocoons.

BLOCK 3: Silk reeling unit management

Unit 1: Management of silk reeling unit

Reeling unit management – organization set up, raw materials- cocoons, fuel, water.

Unit 2: Constraints and risk management

Manpower, procurement skills – constraints, marketing – case studies of charka, cottage basin and filature basin, management of by-products of sericulture – risk management / non-cash input management.

PRACTICALS

1. Study of concept, principals, management and resource management in sericulture
2. Study of organizational set up in Sericultural organizations
3. Producing planning for grainage
4. Raw material management
5. Reeling unit management: man power, raw material, fuel and water
6. Planning for establishment of Chawki Rearing Centre (CRC)
7. Planning for establishment of grainage
8. Study of by-products in sericulture
9. Record maintenance in sericulture activities
10. Study of leaf production and supply chain management
11. Risk management / non cash management in sericulture
12. Visit to grainage and CRC
13. Case study: chawki rearing unit and silk cocoon production
14. Case studies: silkworm seed production unit

15. Case studies: filature and cottage basin units
16. Case studies: Charaka unit, improved Charaka units
17. Visit to seed cocoon markets
18. Visit to silk reeling units

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Text Books / Publication reviews
- Class presentations and assignments
- Experimentation
- Group discussion
- Group work
- Laboratory exercises
- Scientific journals and periodicals
- Study visits

RESOURCES

1. ANONYMOUS., 2002, *Silk Weaving*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
2. ANONYMOUS, 2002, *Colours from Nature – Silk Dyeing Using Natural Dyes*. Vol. I and II, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
3. BERNARD, P. AND CORBMAN, 1983, *Textiles: Fiber to Fabric*. 6th Edition, Mc. Graw – Hill International Editions, Home Economic Series, Singapore, p. 594.
4. CHARLES J. HUBER, 1929, *The Raw Silk Industry of Japan*. The Silk Association of America, Inc., New York.
5. DANDIN, S.B. AND GUPTA, V.P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
6. DANDIN, S.B., JAYANT JAYASWAL. AND GIRIDHAR, K., (Eds.), 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore.
7. DATTA, R.K., 1996, *Global Silk Scenario – 2001. Proceedings the International Conference on Sericulture – 1994*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
8. GOVINDAN, R., CHINNASWAMY, K.P., KRISHNAPRASAD, N.K. AND REDDY, D.N.R., 2000, *Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension. Vol. 3– Proceedings of NSTS – 1999*, UAS, Bangalore.
9. SANJAY SINHA., 1990, *The Development of Indian Silk*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

10. TRIPURARI SHARAN., 1984, *Sericulture and Silk Industry*. Published by Y.K. Sharma, Consortium on Rural Technology, Delhi.

List of Journals and r-Resource

- *Bulletins of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Current Science* – Published by C.V. Raman Institute of Science, Bangalore.
- *Reshme Krishi* (Kannada) - Published by Department of Sericulture, Government of Karnataka, Bangalore.

WEBSITES

- csb.gov.in/
- <https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf>
- www.tnau.ac.in
- www.csrtimys.res.in