

VOL.  
1



Agriculture and Allied Sciences

# Restructured and Revised Syllabi of Post-graduate Programmes

- Plant Sciences
- Plant Protection
- Horticultural Sciences
- Forestry
- Sericulture



Education Division

Indian Council of Agricultural Research  
New Delhi

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त्रिलोचन महापात्र, पीएच.डी.

एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस

सचिव एवं महानिदेशक

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## Foreword

THE ICAR has been continuously striving to bring necessary reforms for quality assurance in agricultural education. The Council has appointed National Core Group and BSMA Committees for revision and restructuring of Post-graduate and Doctoral syllabi in consultation with all the stakeholders to meet the challenges and harness opportunities in various disciplines of agriculture and allied sciences. It has been observed that a paradigm shift is necessary in academic regulations to comply with various provisions of National Education Policy-2020. It is heartening to note that the respective Committees have taken due care by following flexible, multi-disciplinary and holistic approach while developing the syllabus and academic regulations. The students are given opportunities to select the courses to support their planned research activities, to register for online courses and to pursue internship for development of entrepreneurship during Masters' programme. Further, the Teaching Assistantship has been introduced to provide experience to the Ph.D. scholars on teaching, evaluation and other related academic matters. This is an important part of doctoral training all over the world and it is expected to address the shortage of faculty in many institutions/universities. By intensive discussion with the subject experts and based on the feedback from the faculty and students, the syllabus of Masters' and Doctoral programmes in 79 disciplines was restructured and new courses were introduced. The syllabus has been revised suitably with the view to equip the students to gain knowledge, enhance their employability and skill sets to mould towards entrepreneurship and build themselves to prepare for global competitiveness. The opinions and suggestions invited from the concerned institutions, eminent scientists and other stakeholders were also reviewed by the Committees.

The Council sincerely thanks Dr Arvind Kumar, Chairman of the National Core Group and its members for the guidance to develop the syllabus in line with contemporary and projected national and global agricultural trends. The Council acknowledges the dedicated efforts and contribution of all the Chairpersons and members of 19 BSMA Committees for preparation of the syllabus. It gives me immense pleasure to express profuse thanks to the Agricultural Education Division for accomplishing this mammoth task under the guidance of Dr N.S. Rathore, former DDG and Dr R.C. Agrawal, DDG. I compliment Dr G. Venkateshwarlu, former ADG (EQR) for his sincere efforts and overall coordination of the meetings. Special thanks to DKMA for bringing out the entire syllabus in six volumes.

(T. Mohapatra)

Date: 13th August 2021

Place: New Delhi-110 001

## Preface

THE curricula development is a part of the continued process and effort of the ICAR in this direction for dynamic improvement of national agricultural education system. In this resolve, the ICAR has constituted a National Core Group (NCG) for restructuring of Master's and Ph.D. curriculum, syllabi and academic regulations for the disciplines under agricultural sciences. On the recommendations of the NCG, 19 Broad Subject Matter Area (BSMA) Committees have been constituted by the ICAR for revising the syllabus. These Committees held discussions at length in the meetings and workshops organized across the country. The opinions and suggestions invited from institutions, eminent scientists and other stakeholders were also reviewed by the Committees. The respective BSMA Committees have examined the existing syllabus and analysed carefully in terms of content, relevance and pattern and then synthesized the new syllabus.

The revised curricula of 79 disciplines has been designed with a view to improve the existing syllabus and to make it more contextual and pertinent to cater the needs of students in terms of global competitiveness and employability. To mitigate the concerns related to agriculture education system in India and to ensure uniform system of education, several changes have been incorporated in common academic regulations in relation to credit load requirement and its distribution, system of examination, internship during Masters programme, provision to enrol for online courses and take the advantage of e-resources through e-learning and teaching assistantship for Ph.D. scholars. As per recommendations of the National Education Policy-2020, the courses have been categorized as Major and Minor/Optional courses. By following the spirit of Choice Based Credit System (CBCS), the students are given opportunity to select courses from any discipline/department enabling the multi-disciplinary approach.

We place on record our profound gratitude to Dr Trilochan Mohapatra, Director General, ICAR, New Delhi, for providing an opportunity to revise the syllabi for PG and Ph.D. programs in agriculture and allied sciences. The Committee is deeply indebted to Dr R.C. Agrawal, DDG (Agri. Edn), and to his predecessor Dr N.S. Rathore for their vision and continuous support. Our thanks are due to all Hon'ble Vice Chancellors of CAUs/SAUs/DUs for their unstinted support and to nominate the senior faculty from their universities/institutes to the workshops organized as a part of wider consultation process.

The revised syllabi encompass transformative changes by updating, augmenting, and revising course curricula and common academic regulations to achieve necessary quality and need-based agricultural education. Many existing courses were upgraded with addition and deletion as per the need of the present situation. The new courses have been incorporated based on their importance and need both at national and international level. We earnestly hope that this document will meet the needs and motivate different stakeholders.

G. Venkateshwarlu  
Member-Secretary

Arvind Kumar  
Chairman, National Core Group

## Overview

A National Core Group has been constituted by ICAR for development of Academic Regulations for Masters and Ph.D. programmes, defining names and curricula of Masters' and Ph.D. disciplines for uniformity and revision of syllabi for courses of Masters' and Ph.D. degree disciplines. On the recommendations of the members of National Core Group, 19 Broad Subject Matter Area (BSMA) Committees have been constituted for revising the syllabus. These committees have conducted several meetings with the concerned experts and stakeholders and developed the syllabus for their respective subjects. While developing the syllabi, various provisions of National Education Policy-2020 have also been considered and complied to provide quality higher education and develop good, thoughtful, well-rounded, and creative individuals. Necessary provisions have been made in the curricula to enable an individual to study major and minor specialized areas of interest at a deep level, and also develop intellectual curiosity, scientific temper and creativity.

I express my gratefulness to Dr Arvind Kumar, Vice-Chancellor, Rani Lakshmi Bai Central Agricultural University, Jhansi and Chairman, National Core Group under whose guidance the syllabi for Master's and Doctoral programme is completed. His vast experience in agricultural education and research helped in finalising the syllabi. I wish to place on record the suggestions and directions shown by Dr N.S. Rathore, former Deputy Director General (Education) and Dr G. Venkateswarlu, ADG (EQR) and Member Secretary, National Core Group throughout the period without which the present target could not have been achieved. I am extremely thankful to 19 BSMA Committees for their stupendous job in restructuring and articulating curricula in the light of technological developments and employability prospects in agriculture and allied sciences. I also appreciate and acknowledge the efforts made by Dr S.K. Sankhyan, Principal Scientist (EQR), Dr S.K. Singh, Project Director (DKMA), Mr Punit Bhasin, Incharge, Production Unit (DKMA), Dr Kshitij Malhotra and Dr Sumit Saini, Research Associates to take up the work of editing, proof reading, finalizing and bringing out these six volumes of BSMA in this shape.

I also take this opportunity to express a deep sense of gratitude to Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for his guidance, cordial support and valuable input throughout the revision of the syllabus by BSMA, which helped in completing this task through various stages. The support and help extended by all Deputy Director Generals and the staff of Education Division is also greatly acknowledged.

During this comprehensive exercise of upgrading the course contents, the much-needed academic support, hospitality and participation rendered by Hon'ble Vice-Chancellors of CAUs/SAUs/DUs is greatly acknowledged. My deep sense of gratitude goes to Deans, Directors, Professors, Heads, faculty members and students at the universities who contributed by their effective participation and interaction.

R.C. Agrawal

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# Common Academic Regulations for PG and Ph.D. Programmes

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  - 6.1 Prevention of plagiarism
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8. Internship during Masters programme
9. Teaching assistantship
10. Registration of project personnel (SRF/ RA) for Ph.D.
11. Compliance with the National Education Policy-2020
12. Definitions of academic terms

## **1. Academic Year and Registration**

- An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end examination, end of semester and academic year, etc. The Academic Calendar shall be developed by the concerned University from time to time and notified accordingly by the Registrar in advance.
- An orientation programme shall be organized by the Director (Education)/ Dean PGS for the benefit of the newly admitted students immediately after commencement of the semester.
- On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified in the Academic/ Semester Calendar or specifically notified separately. Every enrolled student shall be required to register at the beginning of each semester till the completion of his/ her degree programmes.

## **2. Credit requirements**

### **2.1 Framework of the courses**

The following nomenclature and Credit Hrs need to be followed while providing the



syllabus for all the disciplines:

	Masters' Programme	Doctoral Programme
<b>(i) Course work</b>		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	–
Seminar	01	02
<b>(ii) Thesis Research</b>	30	75
Total	70	100

**Major courses:** From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given \*mark

**Minor courses:** From the subjects closely related to a student's major subject

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

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

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

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

## 2.2 Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following 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:

Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1





Course Code	Course Title	Credit Hours
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

### 2.3 Syllabus of Common Courses for PG programmes

#### **LIBRARY AND INFORMATION SERVICES (0+1)**

##### **Objective**

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

##### **Practical**

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

#### **TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)**

##### **Objective**

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

##### **Practical (Technical Writing)**

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;



- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

### **Suggested Readings**

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

## **INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)**

### **Objective**

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

### **Theory**

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National



Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

### Suggested Readings

1. Erbisch FH and Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

## BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

### Objective

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

### Practical

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

### Suggested Readings

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



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

## **AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)**

### **Objective**

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

### **Theory**

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

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

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

### **Suggested Readings**

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

#### **2.4 Mandatory requirement of seminars**

- It has been agreed to have mandatory seminars one in Masters (One Credit) and two in Doctoral programmes (two Credits).
- The students should be encouraged to make presentations on the latest developments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

#### **3. Residential requirements**

- The minimum and maximum duration of residential requirement for Masters'



Degree and Ph.D. Programmes shall be as follows:

P.G. Degree Programmes	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years (4 Semesters)	5 Academic Years (10 Semesters)
Ph.D.*	3 Academic Years (6 Semesters)	7 Academic Years (14 Semesters)

\*Student may be allowed to discontinue temporarily only after completion of course work

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits his/ her thesis any time during the 4<sup>th</sup> and 6<sup>th</sup> semester of his/ her residency at the University for Masters' and Ph.D. programme, respectively.

#### 4. Evaluation of course work and comprehensive examination

- For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc. students.
- For Ph.D., the approach should be research oriented rather than exam oriented. In order to provide the student adequate time to concentrate on the research work and complete the degree in stipulated time, the examination may have to be only semester final. However, the course teacher may be given freedom to evaluate in terms of assignment/ seminar/ first test.
- For Ph.D., the comprehensive examination (Pre-qualifying examination) is required. As the students are already tested in course examinations, the comprehensive examination should be based on oral examination by an external expert and the evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic. The successful completion of comprehensive examination is to obtain the "Satisfactory" remark by the external expert.

#### 5. Advisory System

##### 5.1 Advisory Committee

- There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree and four in the case of Ph.D. degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the Post-graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of two years or more may be included in the Advisory Committee as member representing the minor.
- At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (including Master's and Ph.D. programmes) for more than five students.



- The Advisor should convene a meeting of the Advisory Committee at least once in a Semester. The summary record should be communicated to the Head of Department, Dean of the College of concerned, Director (Education)/ Dean PGS and Registrar for information.

#### **Advisor/ Co-guide/ Member, Advisory Committee from other collaborating University/ Institute/ Organization**

- In order to promote quality Post-graduate research and training in cutting edge areas, the University may enter into Memorandum of Understanding (MOU) with other Universities/ Institutions for conducting research. While constituting an Advisory Committee of a student, if the Chairperson, Advisory Committee feels the requirement of involving of a faculty member/ scientist of such partnering university/ Institute/ Organization, he/ she may send a proposal to this effect to Director (Education)/ Dean PGS along with the proposal for consideration of Student's Advisory Committee (SAC).
- The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/ Member, SAC, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution. The faculty member/ scientist of partnering institutions in the SAC shall become a temporary faculty member of the University by following the procedure approved by the Academic Council.

#### **Allotment of students to the retiring persons**

Normally, retiring person may not be allotted M. Sc. Student if he/ she is left with less than 2 years of service and Ph.D. student if left with less than 3 years of service. However, in special circumstances, permission may be obtained from the Director (Education)/ Dean PGS, after due recommendation by the concerned Head of the Department.

Changes in the Advisory Committee:

- (i) Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be effected with due approval of the Director of Education/ Dean PGS.
- (ii) Normally, staff members of the university on extra ordinary leave or on study leave or who leave the University service will cease to continue to serve as advisors of the Post-graduate students of the University. However, the Director (Education)/ Dean PGS may permit them to continue to serve as advisor subject to the following conditions:
  - (a) The concerned staff member must be resident in India and if he/ she agrees to guide research and must be available for occasional consultations;
  - (b) An application is made by the student concerned duly supported by the Advisory Committee;
  - (c) In case of a Ph.D. student, he/ she must have completed his/ her comprehensive examinations and the research work must be well in progress and it is expected that the student will submit the thesis within a year;
  - (d) The Head of the Department and the Dean of the College concerned agree to the proposal;



- (e) The staff member, after leaving the University service is granted the status of honorary faculty's membership by the Vice-Chancellor on the recommendation of the Director (Education)/ Dean PGS for guiding as Chairperson or Member, Advisory Committee the thesis/ theses of the student(s) concerned only.
- (iii) In case the Chairperson/ member of a Student's Advisory Committee retires, he/ she shall be allowed to continue provided that the student has completed his course work and minimum of 10 research credits and the retiring Chairperson/ member stays at the Headquarters of the College, till the thesis is submitted.
- (iv) If the Chairperson/ member proceeds on deputation to another organization, he/ she may be permitted to guide the student provided his/ her new organization is at the Headquarters of the College and his/ her organization is willing for the same.
- (v) The change shall be communicated to all concerned by the Head of Department.

## **6. Evaluation of research work**

- It is highly desirable for Ph.D. programme and this should be done annually as an essential part of research evaluation. The Student Advisory Committee shall review the progress of research and scrutinize annual progress reports submitted by the student.
- Midterm evaluation of Ph.D. (to move from JRF to SRF) is a mandatory requirement for all the funding agencies. Hence, the second review of annual progress report need to be done after completion of two years. The successful completion enables the students to become eligible for SRF.

### **6.1 Prevention of plagiarism**

- An institutional mechanism should be in place to check the plagiarism. The students must be made aware that manipulation of the data/ plagiarism is punishable with serious consequences.

## **7. Learning through online courses**

- In line with the suggestion in new education policy and the initiatives taken by ICAR and MHRD in the form of e-courses, MOOCs, SWAYAM, etc. and also changes taking place globally in respect of learning through online resources it has been agreed to permit the students to enrol for online courses. It is expected that the provision of integrating available online courses with the traditional system of education would provide the students opportunities to improve their employability by imbibing the additional skills and competitive edge.

The Committee recommends the following points while integrating the online courses:

1. Board of Studies (BoS) of each Faculty shall identify available online courses and a student may select from the listed courses. The interested students may provide the details of the on-line courses to the BoS for its consideration.
2. A Postgraduate student may take up to a maximum of 20% credits in a semester through online learning resources.
3. The host institute offering the course does the evaluation and provide marks/ grades. The BoS shall develop the conversion formula for calculation of GPA and it may do appropriate checks on delivery methods and do additional evaluations, if needed.

## 8. Internship during Masters programme

Internship for Development of Entrepreneurship in Agriculture (IDEA)

Currently, a provision of 30 credits for dissertation work in M.Sc./ M.Tech/ M.F.Sc./ M.V.Sc. programmes helps practically only those students who aspire to pursue their career in academic/ research. There is hardly any opportunity/ provision under this system to enhance the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, an optional internship/ in-plant training (called as IDEA) in lieu of thesis/ research work is recommended which will give the students an opportunity to have a real-time hands-on experience in the industry.

It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhanced partnerships between academia and industry.

The main objectives of the programme:

1. To promote the linkages between academia and industry
2. To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization
3. Collaboration between Universities and industries through pilot projects
4. To develop methods for knowledge transfer, innovation and networking potential
5. To enhance skill, career development and employability

Following criteria for IDEA will be taken into consideration:

- At any point of time there will not be more than 50% of students who can opt under IDEA
- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry
- Total credits (30) will be divided into 20 for internship/ in-plant training and 10 for writing the report followed by viva-voce similar to dissertation
- Work place will be industry; however, academic/ research support would be provided by the University or both. MoU may be developed accordingly
- The IPR, if any, would be as per the University policy

## 9. Teaching assistantship

- Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters. This is an important part of Ph.D. training all over the world and it is expected to address the shortage of faculty in many institutions/ universities.
- The fulltime doctoral students of the University with or without fellowship may be considered for award of Teaching Assistantships in their respective Departments. The Teaching Assistantship shall be offered only to those doctoral students who have successfully finished their course work. Any consideration for award of Teaching Assistantships must have the consent of the supervisor concerned.
- Teaching Assistantships shall be awarded on semester to semester basis on the recommendation of a screening/ selection committee to be constituted by the





ViceChancellor. All classes and assignments given to the Teaching Assistants, including tutorials, practicals and evaluation work shall be under the supervision of a faculty member who would have otherwise handled the course/ assignment.

- Each Ph.D. student may be allowed to take a maximum of 16 classes in a month to UG/ Masters students.
- No additional remuneration shall be paid to the students who are awarded ICAR JRF/ SRF. The amount of fellowship to be paid as remuneration to other students (who are receiving any other fellowship or without any fellowships) may be decided by the concerned universities as per the rules in force. However, the total amount of remuneration/ and fellowship shall not exceed the amount being paid as JRF/ SRF of ICAR.
- At the end of each term, Teaching Assistants shall be given a certificate by the concerned Head of the Department, countersigned by the School Dean, specifying the nature and load of assignments completed.

#### **10. Registration of project personnel (SRF/ RA) for Ph.D.**

- A provision may be made to enable the project personnel (SRF/ RA) to register for Ph.D. However, this can be done only if they are selected based on some selection process such as walk-in-interview. The prior approval of PI of the project is mandatory to consider the application of project personnel (SRF/ RA) for Ph.D. admission
- The candidates need to submit the declaration stating that the project work shall not be compromised because of Ph.D. programme. Further, in order to justify the project work and Ph.D. programme, the number of course credits should not be more than 8 in a semester for the project personnel (SRF/ RA) who intend to register for Ph.D.

#### **11. Compliance with the National Education Policy-2020**

- While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:
- Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and 21st century capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020).
- At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier,



cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020).

- Flexibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020).
- As part of a holistic education, students at all HEIs will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/ research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).
- HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centres; centres in frontier areas of research; greater industry-academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).
- Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High-quality pedagogy is then necessary to successfully impart the curricular material to students; pedagogical practices determine the learning experiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

## Definitions of Academic Terms

**Chairperson** means a teacher of the major discipline proposed by the Head of Department through the Dean of the College and duly approved by the Director of Education/ Dean Post Graduate Studies (or as per the procedure laid down in the concerned University regulations) to act as the Chairperson of the Advisory Committee and also to guide the student on academic issues.

**Course** means a unit of instruction in a discipline carrying a specific number and credits to be covered in a semester as laid down in detail in the syllabus of a degree programme.

**Credit** means the unit of work load per week for a particular course in theory and/ or practical. One credit of theory means one class of one clock hour duration and one credit practical means one class of minimum two clock hours of laboratory work per week.

**Credit load** of a student refers to the total number of credits of all the courses he/ she registers during a particular semester.

**Grade Point (GP)** of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, expressed and rounded off to second decimal place.

**Credit Point (CP)** refers to the Grade point multiplied by the number of credits of the course, expressed and rounded off to second decimal place.

**Grade Point Average (GPA)** means the total credit point earned by a student divided by total number of credits of all the courses registered in a semester, expressed and rounded off to second decimal place.

**Cumulative Grade Point Average (CGPA)** means the total credit points earned by a student divided by the total number of credits registered by the student until the end of a semester (all completed semesters), expressed and rounded off to second decimal place.

**Overall Grade Point Average (OGPA)** means the total credit points earned by a student in the entire degree programme divided by the total number of credits required for the P.G. degree, expressed and rounded off to second decimal place.

# Acknowledgements

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This BSMA committee wishes to place on record the encouragement, suggestions and directions shown by Dr N.S. Rathore, former DDG (Education); Dr R.C. Agrawal, DDG (Education); Dr G. Venkateswarlu, ADG (EQR) and Member Secretary and Dr K.L. Khurana, Principal Scientist, Education Division of ICAR, New Delhi throughout the entire period without which the present target could not have been achieved.

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**Z.S. Solanki**  
Chairman  
and  
Former V.C., Agril. Uni., Kota.

## Preamble

(Entomology)

Plant improvement has a long history for its growth and development. Plant breeding became established as a science in the twentieth century following the rediscovery of Mendel's laws of inheritance. Nearly 50% of global increase in food production is attributed to plant breeding. Since genetic improvement in an inherent feature, products of plant breeding can have wide global impact as exemplified by the Green Revolution for wheat and rice varieties of 1960s or transgenic crops of recent decades. Therefore developing sufficient human resources in Genetics and Plant Breeding with advanced knowledge and technical skill will further elevate the agricultural sector to attain a new peak in increasing food production matching the requirement of population.

Present agriculture research and international market demand the need for specialised human resource for teaching cutting edge technology with application of biotechnology, nanotechnology, artificial intelligence in crop improvement, increasing entrepreneurship etc, would warrant students to have strong knowledge of practical and management skills which will help them to face the competitiveness in public and private sector.

Hence, restructuring of course curricula and delivery system to match with the present situation is the need of the time. In this proposed revision of curriculum in Genetics and Plant Breeding, the BSMA sub-group organized a series of meetings and electronic media-led consultations to develop a set of courses suitable for M.Sc. and Ph.D. students of the discipline.

The meetings were focussed on the basic principles as well as the innovative developments in Genetics and Plant Breeding, as the platform building status of Plant Sciences. Built on this platform with the latest state of the art technologies including biotechnology and molecular biology will enable a complete coverage of the subjects. The basic courses have therefore been kept as compulsory courses which need to be taken by all the students irrespective of the subject specialization or stream from which they entered into PG education.

The BSMA Committee had thread bare discussions over four sessions on the topical issues concerning Genetics and Plant Breeding, Seed Science and Technology and Plant Genetic Resources. The curricula and syllabi of all these disciplines were discussed at length in the meetings and workshops. The opinions and suggestions invited from institutions, eminent scientists and other stakeholders were also reviewed by the committee. The new look and restructured PG programmes in Genetics and Plant Breeding have been designed in considerations based on demands of private sector harnessing commercial aspects, modern research tools and their applications, supplementary skills required, and to enhance the global competitiveness and employability of our students. Considerable efforts have, therefore gone in for the preparation of this document.

Many existing courses were upgraded with addition and deletion as per the need of the present situation. The new courses have been incorporated based on their importance and social need both at national and international level are Molecular Breeding and Bioinformatics, Breeding for Quality and Special Traits, Seed Production and Certification, Breeding Vegetable Crops, Breeding Fruit Crops, Breeding Ornamental Crops for M.Sc. and IPR and Regulatory Mechanism (e-course) as well as Population Genetics for Ph.D. programme.



## Course Title with Credit Load

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

Course Code	Course Title	Credit Hours
ENT 501*	Insect Morphology	3 (2+1)
ENT 502*	Insect Anatomy and Physiology	3 (2+1)
ENT 503*	Insect Taxonomy	3 (1+2)
ENT 504*	Insect Ecology	3 (2+1)
ENT 505*	Biological Control of Insect Pests and Weeds	3 (2+1)
ENT 506*	Toxicology of Insecticides	3 (2+1)
ENT 507	Host Plant Resistance	2 (1+1)
ENT 508*	Concepts of Integrated Pest Management	2 (2+0)
ENT 509*	Pests of Field Crops	3 (2+1)
ENT 510*	Pests of Horticultural and Plantation Crops	3 (2+1)
ENT 511*	Post Harvest Entomology	2 (1+1)
ENT 512	Insect Vectors of Plant Pathogens	2 (1+1)
ENT 513	Principles of Acarology	2 (1+1)
ENT 514	Vertebrate Pest Management	2 (1+1)
ENT 515	Techniques in Plant Protection	1 (0+1)
ENT 516	Apiculture	3 (2+1)
ENT 517	Sericulture	3 (2+1)
ENT 518	Lac Culture	3 (2+1)
ENT 519	Molecular Approaches in Entomology	3 (2+1)
ENT 520	Plant Quarantine, Biosafety and Biosecurity	2 (2+0)
ENT 521	Edible and Therapeutic Insects	2 (1+1)
ENT 522	Medical and Veterinary Entomology	2 (1+1)
ENT 523	Forest Entomology	2 (1+1)
ENT 591	Master's Seminar	1 (0+1)
ENT 599	Master's Research	30 (0+30)

\*Compulsory Major Courses

## Course Contents

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

- I. Course Title** : Insect Morphology  
**II. Course Code** : ENT 501  
**III. Credit Hours** : 3 (2+1)

#### IV. Aim of the course

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

#### V. Theory

##### Unit I

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

Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites.

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications.

Abdomen- Segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development.

##### Unit II

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

##### Unit III

Types of immature stages in insect orders, morphology of egg, nymph/ larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

#### VI. Practical

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

#### VII. Learning outcome

- Students are expected to have a complete understanding of the comparative



morphology of the external features of insects that can be utilized in taxonomy, ecology and applied entomology.

### VIII. Suggested Reading

- Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.
- Chu HF. 1992. *How to Know Immature Insects*. William Brown Publication, Iowa.
- Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.
- Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.
- Gillott C. 1995. *Entomology*, 2<sup>nd</sup> Ed. Plenum Press, New York, London.
- Gullan PJ and Cranston PS. 2000. *The Insects, An Outline of Entomology*, 2<sup>nd</sup> Ed. Blackwell Science, UK.
- Peterson A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.
- Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10<sup>th</sup> Ed. Chapman and Hall, London.
- Snodgrass RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.
- Tembhore DB. 2000. *Modern Entomology*, Himalaya Publishing House, Mumbai.
- Steher FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publication, Iowa.

**I. Course Title : Insect Anatomy and Physiology**

**II. Course Code : ENT 502**

**III. Credit Hours : 3 (2+1)**

#### IV. Aim of the course

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

#### V. 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 and endocrine glands) and nerve impulse transmission in insects.

##### Unit III

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

#### VI. 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.

#### VII. Learning outcome

- Students are expected to have a thorough understanding of insect growth and development, physiology of exoskeleton, endoskeleton and different organ systems;





action and role of hormones, pheromones, physiology of nutrition and its application.

### VIII. Suggested Reading

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

**I. Course Title : Insect Taxonomy**

**II. Course Code : ENT 503**

**III. Credit Hours : 3 (1 + 2)**

### IV. Aim of the course

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

### V. Theory

#### Unit I

History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions-subjects of descriptions, characters, nature of characters, analogy *v/s* homology, parallel *v/s* convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects-introduction to phylogeny of insects and Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systematics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labeling protocols and procedures.

#### Unit II

Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.



### Unit III

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

### VI. 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.

### VII. Learning outcome

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

### VIII. Suggested Reading

- CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2<sup>nd</sup> Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
- Freeman S and Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.
- Gullan PJ and Cranston PS. 2010. *The Insects: An outline of Entomology*. 4<sup>th</sup> 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*. 10<sup>th</sup> Ed. Chapman and Hall, London.
- Ross HH. 1974. *Biological Systematics*. Addison Wesley Publ. Company.
- Triplehorn CA and Johnson NF. 1998. *Borrer and DeLong's Introduction to the Study of Insects*. 7<sup>th</sup> Ed. Thomson/ Brooks/ Cole, USA/ Australia.

**I. Course Title : Insect Ecology**

**II. Course Code : ENT 504**

**III. Credit Hours : 3 (2+1)**

### IV. Aim of the course

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

### V. 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.

## VI. 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.

## VII. Learning outcome

- The students are expected to be well versed with the basic concepts of ecology, ecological succession, population ecology, community ecology, nutritional ecology and different insect-ecosystem interactions
- Quantification of insect diversity and abundance, life table analyses, predator-prey and host-parasitoid relations, functional and numerical responses, niche breadth and overlap

## VIII. Suggested Reading

- Begon M, Townsend CR and Harper JL. 2006. *Ecology: From Individuals to Ecosystems*. 4<sup>th</sup> Ed. Blackwell Publishing, USA/ UK/ Australia.
- Chapman JL and Reiss MJ. 2006. *Ecology: Principles and Applications*. 2<sup>nd</sup> Ed. Cambridge Univ. Press, Cambridge.
- Fowler J, Cohen L and Jarvis P. 1998. *Practical Statistics for Field Biology*. 2<sup>nd</sup> Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.
- Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc., Sunderland, MA.
- Gotelli NJ. 2001. *A Primer of Ecology*. 3<sup>rd</sup> Ed. Sinauer Associates, Inc., Sunderland, MA
- Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.
- Krebs CJ. 1998. *Ecological Methodology*. 2<sup>nd</sup> Ed. Benjamin-Cummings Publ. Co., New York.
- Krebs CJ. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance*. 5<sup>th</sup> Ed. Benjamin-Cummings Publ. Co., New York.
- Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton Univ. Press, Princeton.
- Price PW. 1997. *Insect Ecology*. 3<sup>rd</sup> 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*. 3<sup>rd</sup> Ed. Academic Press, London, UK/ CA, USA.
- Southwood TRE and Henderson PA. 2000. *Ecological Methods*. 3<sup>rd</sup> 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*. 3<sup>rd</sup> Ed. Blackwell Publishing, USA/ UK/ Australia.
- Wilson EO, William H and 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.

**I. Course Title : Biological Control of Insect Pests And Weeds**

**II. Course Code : ENT 505**

**III. Credit Hours : 3 (2+1)**

## IV. Aim of the course

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

## V. Theory

### Unit I

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



## Unit II

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

## Unit III

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

## Unit IV

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

## VI. Practical

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

## VII. Learning outcome

- Students are expected to have a good understanding of the role of natural enemies in managing pest populations below those causing economic damage
- Learn the techniques for mass production of quality bio-agents and their optimal use in IPM

## VIII. Suggested Reading

- Burges HD and Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
- De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman and Hall, New York.
- Dhaliwal GS and Arora R. 2001. *Integrated Pest Management: Concepts and Approaches*. Kalyani Publishers, New Delhi.
- 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.

- I. Course Title** : **Toxicology of Insecticides**
- II. Course Code** : **ENT 506**
- III. Credit Hours** : **3 (2+1)**
- IV. Aim of the course**

To orient the students with structure and mode of action of important insecticides

belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

## V. 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 pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

### Unit III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides-synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. bioassay definition, objectives, criteria, factors, problems and solutions.

### Unit IV

Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

### Unit V

Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

## VI. 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.

## VII. Learning outcome

- Students are expected understand the concept of toxicity, bio-efficacy, insecticide formulations, modes of action of insecticides, estimation of insecticide residues and have significant know-how about the functioning of various types of spray equipments.

## VIII. Suggested Reading

Chattopadhyay SB. 1985. *Principles and Procedures of Plant Protection*. Oxford and IBH, New Delhi.



- Dodia DA, Petel IS and Petal GM. 2008. *Botanical Pesticides for Pest Management*. Scientific Publisher (India), Jodhpur.
- Dovener RA, Mueninghoff JC and Volgar GC. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA
- 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.
- Ishaaya I and Degheele D. 1998. *Insecticides with Novel Modes of Action: Mechanism and Application*. Narosa Publishing House, New Delhi.
- Krieger RI. 2001. *Handbook of Pesticide Toxicology*. Vol-II. Academic Press. Orlando Florida.
- Mathews GA. 2002. *Pesticide Application Methods*. 4<sup>th</sup> Ed. Intercept. UK.
- Matsumura F. 1985. *Toxicology of Insecticides*. Plenum Press, New York.
- Otto D and Weber B. 1991. *Insecticides: Mechanism of Action and Resistance*. Intercept Ltd., UK.
- Pedigo LP and Marlin ER. 2009. *Entomology and Pest Management*, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
- 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.
- Roy NK. 2006. *Chemistry of Pesticides*. Asia Printograph Shadara Delhi.

**I. Course Title : Host Plant Resistance**

**II. Course Code : 507**

**III. Credit Hours : 2 (1+1)**

**IV. Aim of the course**

To orient the students with host plant resistance.

**V. Theory**

**Unit I**

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

**Unit II**

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

**Unit III**

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

**Unit IV**

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

**Unit V**

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

**Unit VI**

Role of biotechnology in plant resistance to insects.

**VI. Practical**

- Screening techniques for measuring resistance;

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

#### VII. Learning outcome

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

#### VIII. Suggested Reading

- 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.

**I. Course Title : Concepts of Integrated Pest Management**

**II. Course Code : ENT 508**

**III. Credit Hours : 2 (2+0)**

#### IV. Aim of the course

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

#### V. 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.

#### VI. Learning outcome

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

#### VII. Suggested Reading

- Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publishers, New Delhi.
- Horowitz AR and Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.
- Ignacimuthu SS and Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.
- 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.

**I. Course Title : Pests of Field Crops**

**II. Course Code : ENT 509**

**III. Credit Hours : 3 (2+1)**

#### IV. Aim of the course

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.

#### V. Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.

#### Unit I

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

#### Unit II

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

#### Unit III

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

## VI. 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.

## VII. Learning outcome

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

## VIII. Suggested Reading

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

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

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

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.

**I. Course Title : Pests of Horticultural and Plantation Crops**

**II. Course Code : ENT 510**

**III. Credit Hours : 3 (2+1)**

## IV. Aim of the course

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

## V. Theory

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

### Unit I

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

### Unit II

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

### Unit III

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

### Unit IV

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

## VI. 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.



## VII. Learning outcome

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

## VIII. Suggested Reading

- Atwal AS and Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management*. Kalyani Publishers, New Delhi.
- Butani DK and Jotwani MG. 1984. *Insects and Vegetables*. Periodical Expert Book Agency, New Delhi.
- Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publishers, New Delhi.
- 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.

**I. Course Title : Post Harvest Entomology**

**II. Course Code : ENT 511**

**III. Credit Hours : 2 (1+1)**

## IV. Aim of the course

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

## V. 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.

#### VI. Practical

- Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them;
- Detection of hidden insect infestation in stored food grains;
- Estimation of uric acid content in infested produce; estimation of losses in stored food grains;
- Determination of moisture content in stored food grains;
- Familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques;
- Treatment of packing materials and their effect on seed quality;
- Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, Mysore; IGSMRI, Hapur, etc. (only where logistically feasible).

#### VII. Learning outcome

- Students are expected to acquire knowledge of pestiferous insects, mites, rats and birds affecting stored produce, their nature of damage, life history traits and effective management.
- Detection of insect infestation and familiarization with different storage structures.
- Learning preventive and curative measures to manage infestation in storage houses.

#### VIII. Suggesting Reading

- 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 Publishers, New Delhi.
- Khare BP. 1994. *Stored Grain Pests and Their Management*. Kalyani Publishers, New Delhi.
- Subramanyam B and Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products*. Marcel Dekker, New York.

**I. Course Title : Insect Vectors of Plant Pathogens**

**II. Course Code : ENT 512**

**III. Credit Hours : 2 (1+1)**

#### IV. Aim of the course

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



## V. 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.

## VI. 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.

## VII. Learning outcome

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

## VIII. Suggested Reading

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

**I. Course Title : Principles of Acarology**

**II. Course Code : ENT 513**

**III. Credit Hours : 2 (1+1)**

## IV. Aim of the course

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

## V. 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.

## VI. 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.

## VII. Learning outcome

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

## VIII. Suggested Reading

- 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 Publishers 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.

**I. Course Title : Vertebrate Pest Management**

**II. Course Code : ENT 514**

**III. Credit Hours : 2 (1+1)**

## IV. Aim of the course

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

## V. 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.

## VI. 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.

## VII. Learning outcome

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

## VIII. Suggested Reading

- Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay.
- 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.
- Rahman A. 2020. *Protective and Productive Entomology* Narendra Publishing House, New Delhi

**I. Course Title : Techniques in Plant Protection**

**II. Course Code : ENT 515**

**III. Credit Hours : 1 (0+1)**

## IV. Aim of the course

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

## V. Practical

- Pest control equipments, principles, operation, maintenance, selection, and

- application of pesticides;
- Release of bio-control agents;
  - Seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water;
  - Application of drones in plant protection;
  - Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers;
  - Uses of light, transmission and scanning electron microscopy;
  - Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE;
  - Use of tissue culture techniques in plant protection;
  - Computer application for predicting/ forecasting pest attack and identification.

#### VI. Learning outcome

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

#### VII. Suggested Reading

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

- I. Course Title** : Apiculture  
**II. Course Code** : ENT 516  
**III. Credit Hours** : 3 (2+1)

#### IV. Aim of the course

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

#### V. Theory

##### Unit I

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

##### Unit II

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

##### Unit III

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.

## VI. Practical

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

## VII. Learning outcome

- Students are expected to have a comprehensive knowledge of bee biology, physiology and bee keeping/ apiculture.
- With practical training it is expected that students develop entrepreneurial skills for apiculture.

## VIII. Suggested Reading

- Abrol DP and Sharma D. 2009. *Honey Bee Mites and Their Management*. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2009. *Honey bee Diseases and Their Management*. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2010. *Beekeeping: A Compressive Guide to Bees and Beekeeping*. Scientific Publishers, India.
- Abrol DP. 2010. *Bees and Beekeeping in India*. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2012. *Pollination Biology: Biodiversity Conservation and Agricultural Production*. Springer.
- Atwal AS. 2001. *World of Honey Bees*. Kalyani Publishers, New Delhi- Ludhiana, India.
- Atwal AS. 2000. *Essentials of Beekeeping and Pollination*. Kalyani Publishers, New Delhi- Ludhiana, India.

- Bailey L and Ball BV. 1991. *Honey Bee Pathology*. Academic Press, London.
- Crane Eva and Walker Penelope. 1983. *The Impact of Pest Management on Bees and Pollination*. Tropical Development and Research and Institute, London.
- Free JB. 1987. *Pheromones of Social Bees*. Chapman and Hall, London.
- Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. *Mass Multiplication of Honey Bee Colonies*. ICAR, New Delhi, India.
- Graham Joe M. 1992. *Hive and the Honey Bee*. Dadant & Sons, Hamilton, Illinois, USA.
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- 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.
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**I. Course Title : Sericulture**

**II. Course Code : ENT 517**

**III. Credit Hours : 3 (2+1)**

**IV. Aim of the Course**

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

**V. 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, moultinism, geographical



distribution and genetic nature – pure races –multivoltine and bivoltine races – cross breeds – bivoltine hybrids –Races and hybrids of mulberry, eri, tasar and muga silkworm- Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.

#### Unit IV

Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.

#### Unit V

Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.

### VI. Practical

- Morphology of mulberry plants;
- Identification of popular mulberry genotypes;
- Nursery bed and main field preparation;
- Planting methods;
- Identification of nutrient deficiency symptoms;
- Identification of weeds;
- Pruning and harvesting methods;
- Identification of pests and diseases of mulberry–*Terminalia arjuna*, *Terminalia tomentosa*, Som and Soalu- Nursery and pruning techniques – Intercultural operations;
- Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm egg production technology –Tasar, Eri and muga silkworms – rearing methods–pests and diseases of non-mulberry silkworms – Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.

### VII. Learning outcome

- Students taking up sericulture are expected to have a thorough knowledge of silkworm morphology, races, biology, and all the practices of rearing for silk production.
- They should 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.

### VIII. Suggested Reading

- Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.
- Govindaiah G, VP, Sharma DD, Rajadurai S and Nishita V Naik. 2005. A text book on mulberry crop protection. Central Silk Board, Bangalore.450 p.



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

#### IX. E-resources

[www.silkwormgenomics.org](http://www.silkwormgenomics.org); [www.silkboard.com](http://www.silkboard.com); [ww.silkgermplasm.com](http://ww.silkgermplasm.com); [www.csrtimys.res.in](http://www.csrtimys.res.in)

**I. Course Title : Lac Culture**

**II. Course Code : ENT 518**

**III. Credit Hours : 3 (2+1)**

#### IV. Aim of the course

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

#### V. 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.

### VI. 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.

### VII. Learning outcome

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

### VIII. Suggested Reading

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6<sup>th</sup> Edition, Namrutha Publications, Chennai.

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

- I. Course Title : Molecular Approaches In Entomology**  
**II. Course Code : ENT 519**  
**III. Credit Hours : 3 (2+1)**

### IV. Aim of the course

To acquaint students the latest techniques used in molecular biology.

### V. 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,  $\alpha$ -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.

## VI. 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.

## VII. Learning outcome

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

## VIII. Suggested Reading

- Bhattacharya TK, Kumar P and Sharma A. 2007. *Animal Biotechnology*. 1<sup>st</sup> Ed., Kalyani Publication, New Delhi.
- Hagedorn 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*. 2<sup>nd</sup> 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*. 1<sup>st</sup> Ed., Kalyani Publishers, New Delhi.

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

Singh P. 2007. *Introductory to Biotechnology*. 2<sup>nd</sup> Ed. Kalyani Publishers, New Delhi.

- I. Course Title : Plant Quarantine, Bio-safety and Bio-security**  
**II. Course Code : ENT 520**  
**III. Credit Hours : 2 (2+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. Also, to facilitate students to have a good understanding of the aspects of biosafety and biosecurity.

#### **V. 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.

#### **VI. Learning outcome**

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

#### **VII. 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.

**I. Course Title : Edible and Therapeutic Insects**

**II. Course Code : ENT 521**

**III. Credit Hours : 2 (1+1)**

**IV. Aim of the course**

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

**V. 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.

**VI. 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.

**VII. Learning outcome**

- 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.

**VIII. Suggested Reading**

Halloran A, Flore R, Vantomme P and Roos N 2018. Edible insects in sustainable food systems.  
Van Huis A, Itterbeeck JK, 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.





- I. Course Title** : **Medical and Veterinary Entomology**  
**II. Course Code** : **ENT 522**  
**III. Credit Hours** : **2 (1+1)**

#### **IV. Aim of the course**

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

#### **V. 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 acaricidosis: 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.

#### **VI. 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.

#### **VII. Learning outcome**

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

#### **VIII. Suggested Reading**

- David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6<sup>th</sup> Edition, Namrutha Publications, Chennai.
- Gullan PJ and Cranston PS. 2010. *The Insects: An Outline of Entomology*. 4<sup>th</sup> Edition, Wiley-Blackwell, West Sussex, UK & New Jersey, US.
- Mullen G and Durden L. 2018. *Medical and Veterinary Entomology*, 3<sup>rd</sup> Edition, Academic Press.



- I. Course Title** : **Forest Entomology**  
**II. Course Code** : **ENT 523**  
**III. Credit Hours** : **2 (1+1)**

**IV. Aim of the course**

To promote a more global theoretical understanding of pest population dynamics and the causes of forest insect outbreaks: covering pests of both natural forests and plantations, the diversity of tropical forest insects, their ecological functions, the concept of pests and the incidence of pests in natural forests, plantations and stored timber.

**V. 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.

**VI. 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.

#### **VII. Learning outcome**

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

#### **VIII. Suggested Reading**

- Jha LK and Sen Sarna PK. 1994. *Forest Entomology*. Ashish Publishing House, Delhi.
- Nair KSS. 2007. *Tropical Forest Insect Pests: Ecology, Impact, and Management*, Cambridge University Press, Edinburgh/ New York.
- Stebbing EP. 1977. *Indian Forest Insects*. JK Jain Brothers.