ANNAMALAI UNIVERSITY

(Accredited with 'A' Grade by NAAC)

FACULTY OF AGRICULTURE

(Accredited by ICAR)

DEPARTMENT OF ENTOMOLOGY

Academic Regulations and Syllabi

MASTER OF SCIENCE IN ENTOMOLOGY

Under Choice based credit system (CBCS) with Outcome based Education

2022-2023 Onwards

FACULTY OF AGRICULTURE

Common Regulations for All M.Sc. (Agriculture/Horticulture) and M.B.A. (Agri-Business Management) programmes offered by the Faculty of Agriculture (With effect from 2022-2023)

1. Short title and commencement

- These rules and regulations shall govern the post graduate studies leading to the award of degree of Master of Science (Agriculture/Horticulture) and M.B.A. (Agri. Business Management) in the Faculty of Agriculture.
- They shall come into force with effect from the academic year 2022 – 2023.

2. 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. The Academic Calendar will be developed by the University from time to time and notified accordingly by the Registrar in advance.
- An orientation programme shall be organized by theDean, Faculty of Agriculture 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

3. Registration Card

- A student shall register the courses offered in a semester by writing all the courses in registration card in quadruplicate.
- The Chairman, PG coordinator and Head of the Department are responsible to furnish the registration particulars of the students with their signature in the registration card to the Dean.
- The Dean shall approve the registration card.
- The approved registration card shall be maintained by the Head of the Department, Chairman and the student concerned.
- The list of courses registered by the students in each semester shall be sent by the Head of the Department to the Controller of Examinations/University for preparation of Report Cards

4. Definitions

- **Semester** means an academic term consisting of 110 working days including final theory examinations.
- **Subject** means a unit of instruction to be covered in a semester having specific No., title and credits.
- **Credit hour** means, one hour lecture plus two hours of library or homework or two and half hours of laboratory/field practical per week in a semester.
- **Grade Point of a subject** means the value obtained by dividing the percentage of marks earned in a subject by 10 and the Grade Point is expressed on a 10 point scale.
- **Credit Point** means the grade point multiplied by credit hours.
- **Grade Point Average** (GPA) means the quotient of the total credit points obtained by a student in various subjects at the end of each semester, divided by the total credit hours taken by the student in that semester. The grading is done on a 10 point scale and the GPA has to be corrected to two decimals.
- **Overall Grade Point Average** (OGPA) means the quotient of cumulative credit points obtained by a student in all the subjects taken from the beginning of the first semester of the year divided by the total credit hours of all the subjects which he/she had completed up to the end of a specified semester and determines the overall performance of a student in all subjects during the period covering more than one semester. The OGPA has to be arrived at the second decimal place.

5. Programmes offered

The details of various post-graduate degree programmes at Masters' level offered in the Faculty of Agriculture are as follows:

- M.Sc.(Ag.) Agronomy
- M.Sc.(Ag.) Entomology
- M.Sc.(Ag.) Agricultural Microbiology
- M.Sc.(Ag.) Genetics and Plant Breeding
- M.Sc.(Ag.) Seed Science and Technology
- M.Sc.(Ag.) Molecular biology and Biotechnology
- M.Sc.(Ag.) Plant Pathology
- M.Sc.(Ag.) Soil Science and Agricultural Chemistry
- M.Sc.(Ag.) Agricultural Extension Education
- M.Sc.(Ag.) Agricultural Economics
- M.B.A.(Agri- Business Management)
- M.Sc.(Hort.) Fruit Science
- M.Sc.(Hort.) Vegetable Science
- M.Sc.(Hort.) Floriculture and Landscaping
- M.Sc.(Hort.) Plantation, Spices, Medicinal and Aromatic Crops

6. Eligibility for admission

Candidates for admission to the M.Sc.(Ag./Hort.) and M.B.A.(Agri- Business Management) programme should satisfy the following requirements.

6.1. Candidates seeking admission to the M.Sc. (Ag./Hort.) and M.B.A.(Agri-Business Management) Degree programme should have completed any one of the following four year degree programmes from Faculty of Agriculture, Annamalai University or Universities/colleges accredited with ICAR, New Delhi.

Program of study	Eligibility
M.Sc. (Ag.) Agronomy	B.Sc. (Hons) Agriculture/ B.Sc.(Ag.) courses of four years duration.
M.Sc. (Ag.) Entomology, M.Sc. (Ag.) Genetics and M.Sc. (Ag.) Plant Breeding, M.Sc. (Ag.) Plant Pathology, M.Sc. (Ag.) Soil Science and Agricultural Chemistry, M.Sc. (Ag.) Seed Science and Technology, M.Sc. (Ag.) Molecular biology and Biotechnology, M.Sc. (Ag.) Agricultural Microbiology, M.Sc. (Ag.) Agricultural Extension Education, M.Sc. (Ag.) Agricultural Economics and M.B.A. (Agri. Business Management)	B.Sc. (Hons) Agriculture / B.Sc. (Hons) Horticulture/ B.Sc. (Ag.)/ B.Sc. (Hort.) of four years duration.
M.Sc. (Hort.) Fruit Science M.Sc. (Hort.) Vegetable Science M.Sc. (Hort.) Floriculture and Landscaping M.Sc. (Hort.) Plantation, Spices, Medicinal and Aromatic Crops	B.Sc. (Hons) Agriculture / B.Sc. (Hons) Horticulture/ B.Sc.(Hort.) and B.Sc. (Ag.) courses of four years duration.

6.2. Candidates who have undergone the programme under conventional system should possess not less than a second class Bachelor's degree. The candidates under 4 point grade systems should possess a minimum OGPA of 2.5 out of 4.00 and 2.75 out of 4.00 in the subject concerned. For those under 10 point system a minimum OGPA of 6.50 out of 10.00 and 7.00 out of 10.00 in the subject concerned is required. However, for SC/ST candidates OGPA of 6.75 out of 10.00 in the subject concerned is sufficient.

6.3.An entrance test will be held separately for each Degree programme. Selection of candidates shall be based on OGPA, Subject OGPA, Entrance Test and Interview.

6.4. A student can apply to a maximum of two subjects only.

7. Programme Requirements

7.1. Residential requirements

The duration for the M.Sc. (Agriculture/Horticulture) and MBA programme will be of two years with four semesters. A student registered for M.Sc. (Agriculture/Horticulture) programme should complete the course within five academic years from the date of his/her admission. In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled.

7.2. Credit Grade Point Requirements

A student enrolled for the Master's degree programme to earn eligibility for thedegree is required to complete 70 credits as detailed below.

Course work	**Credit**
Major Courses	20
Minor Courses	08
Supporting Courses	06
Common Courses	05
Seminar	01
Thesis Research	30
Total credits	**70**

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

7.4 Minor course: From the courses closely related to a student's major subject, minor courses shall be chosen by the students in consultation with the Head of the department and the Chairman based on their research specialization.

7.5 Supporting courses: The subjects 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.

a. List of supporting courses for M.Sc. (Ag.) Agronomy, Agricultural Entomology, Genetics and Plant Breeding, Plant Pathology, Soil Science and Agricultural Chemistry, Seed Science and Technology, Molecular biology and Biotechnology, Agricultural Microbiology and Horticulture are

STA 501 Statistical Methods for Applied Sciences 3(2+1)
COM 501 Information Technology in Agriculture 3(2+1)

b. List of supporting courses for Agricultural Economics and M.B.A (Agri-Business Management)

STA 502 Statistical Methods for social Sciences 3(2+1)
COM 501 Information Technology in Agriculture 3 (2+1)

c. List of supporting courses for M.Sc. (Ag.) Agricultural Extension education,

STA 502 Statistical Methods for social Sciences 3 (2+1)
COM 502 Computer application for Agricultural extension research 3 (2+1)

7.6 Common Courses: There will be five common courses (one credit each) will be offered to all students undergoing Master's degree programme.

Among the five common courses, the following four courses will be offered in all the Master's degree programme:

1. PGS 501- Agricultural Research, Research Ethics and Rural Development Programmes (1+0)
2. PGS 502 - Technical Writing and Communications Skills (0+1)
3. PGS 504- Library and Information Services (0+1)
4. PGS 505- Intellectual Property and its management in Agriculture (1+0)

The fifth common course for Master's degree programme in Agronomy, Entomology, Genetics and Plant Breeding, Seed Science and Technology, Molecular biology and Biotechnology, Plant Pathology, Soil Science and Agricultural Chemistry, Agricultural Microbiology, Fruit Science, Vegetable Science, Floriculture and Landscaping, and Plantation, Spices, Medicinal and Aromatic Crops is

- PGS 503 - Basic Concepts in Laboratory Techniques (0+1)

The fifth common course for Master's degree programme in Agricultural Economics and M.B.A (Agri. Business Management) is

- PGS 507 – Basic Analytical Techniques (0+1)

The fifth common course for Master's degree programme in M.Sc. (Ag.) Agricultural Extension is

- PGS 506 – Basic Laboratory Techniques for Audio and Video Production (0+1)

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).

7.7 Minimum Grade point requirement

A post graduate student should maintain a minimum Grade Point of 6.50 out of 10 to secure a pass in a subject. In the subjects in which a student fails, he/she has to reappear for the examination to get a pass in that subject.

8. Attendance requirement

8.1. One hundred per cent attendance is expected of each student. A student, who fails to secure a minimum of **80 per cent** of attendance in each subject separately for theory and practical, shall not be permitted to appear for the final examination in that subject and will be required to repeat the subject when ever offered.

In case of new admission, who are permitted to join late due to administrative reasons, the attendance will be calculated from the date of joining of the student.

However, for genuine reasons, condonation of attendance deficiency may be considered by the Vice-Chancellor on the recommendation of the Head of the Department and the Dean, Faculty of Agriculture on payment of condonation fee prescribed by the University.

8.2.Students absenting from the classes with prior permission of the Head of the Department/Dean, Faculty of Agriculture on official University business shall be given due consideration in computing attendance.

9. Advisory Committee

9.1. Each post-graduate student shall have an Advisory Committee to guide him/her in carrying out the research programme. The Advisory Committee shall comprise a Major Adviser (Chairman) and two members. Of the two members, one will be from the same Department and the other in the related field from the other Departments of Faculty of Agriculture. The Advisory Committee shall be constituted within three weeks from the date of commencement of the first semester.

9.2.For interdisciplinary research requiring expertise from teaching staff of other faculties, due permission need to be obtained from the Dean, Faculty of Agriculture to nominate them as Technical advisors. An official letter in this regard needs to be communicated to the individual concerned through the respective Head of the Department and Dean. However, they are restrained from the evaluation of Research/Seminar.

9.3. Major Adviser (Chairman)

Every student shall have a Major Adviser who will be from his/her major field of studies. The appointment of Major Adviser (Chairman) shall be made by the Head of the Department concerned. The chairman in consultation with the Head of the Department will nominate the other two members. In the event of the Major Adviser being away on other duty/leave for a period of more than three months, the member of the Advisory Committee from the same Department will officiate as the Major Adviser.

9.4 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 permit the scholar to conduct research in other university/ research institute/ Organization. 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 the Dean, Faculty of Agriculture along with the proposal for consideration of Student's Advisory Committee.

• The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/ Member, Advisory Committee, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution.

9.5 Allotment of students to the retiring persons

Normally, retiring faculty may not be allotted with M. Sc. Student if he/ she is left with less than 2 years of service.

9.6 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 Dean, Faculty of Agriculture.

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 Dean, faculty of Agriculture 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) The Head of the Department and the Dean, Faculty of Agriculture agree to the proposal;

iii. In case the Chairperson/ member of 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. The change shall be communicated to all concerned by the Head of Department.

9.7 Guidelines on the duties of the Advisory Committee

- Guiding students in drawing the outline of research work
- Guidance throughout the programme of study of the students.
- Evaluation of research and seminar credits.
- Correction and finalization of thesis draft.
- Conduct of final Viva-Voce examination.
- The proceedings of the Advisory Committee will be sent to the Head of the Department concerned within 10 working days.
- Periodical review of the Advisory Committee proceedings will be made by the Head of the Department concerned.

10. Programme of Study

10.1.The student's plan for the post-graduate work, drawn up by the Advisory Committee, shall be finalized before the end of the first semester.

10.2.The programme shall be planned by the Advisory Committee taking into account his/her previous academic training and interest.

10.3.Programme of research work

The outline of research work of the student, in the prescribed manner and as approved by the Advisory Committee, shall be forwarded by the Chairman to the Head of the Department concerned by the end of the first semester.

11. Evaluation of Students' Performance

Multiple levels of evaluation (First Test, Midterm and Final semester) will be conducted.

11.1.First Test (FT)

Every teacher handling a subject shall conduct first Test (FT) as per the scheme drawn by the Head of the Department concerned /PG coordinator on the fourth week from the date of registration of the course, and evaluate. The evaluation process will be based on objective type questions and short concepts.

11.2.Mid-semester examination (MSE)

11.2.1.Every teacher handling a subject shall conduct Mid-Semester Examination (MSE) as per the scheme drawn by the Head of the Department concerned /PG coordinator, on the eighth week from the date of registration of the course and evaluate.The evaluation process will be of descriptive type.

11.2.2. The answer scripts of both FT and MSE will be shown to the student after valuation, and returned to the course teacher. The Head of the Department will be responsible to ensure the distribution of answer papers to the students. The marks obtained by the students should be sent to the Controller of Examinations through the Head of the Department concerned within fifteen working days.

11.2.3. Writing the first test and mid-semester examination is a pre-requisite for writing the final theory and practical examinations. If a student does not appear for FT/MSE, he/she is not eligible to appear for the final examinations. Such candidate has to reappear for the FT/MSE as and when the respective examinations are conducted only after getting permission from the Head of the Department concerned.

11.2.4.The FT and MSE marks will not be shown separately in the grade sheet but will be combined with the respective final theory and practical marks. FT and MSE marks awarded in a course will be added to the supplementary examinations also.

11.2.5.The FT and MSE marks will be furnished to the Head of the Department within 10 days after the conduct of Ft and MSE. If the student is not satisfied with the award of the marks, he/she shall appeal to the Dean, through Head of the Department within three working days after the announcement of marks. The appeal will be considered and the results reviewed by a Cell consisting of the Dean and the Head of the Department concerned. The decision of the Review Cell shall be final. If the Head of the Department himself is the course teacher, one senior member of the department concerned shall be nominated by the Dean.

11.2.6. The first test will be of 30 minutes duration and MSE of theory will be of one hour duration.

11.2.7.If the student is not able to write the FT/ MSE due to deputation by the University, he/she may be permitted to take up missing FT/MSE. Such examination should be completed ordinarily within 15 working days after the respective Ft/MSE.

11.2.8.A student who fails to attend a first test and mid-semester examination due to unavoidable circumstances shall be permitted with prior approval of the head of the Department to take up missing examination of the particular course. Such tests should be completed ordinarily within 15 working days after the respective FT/MSE.

The distribution of marks will be as indicated below.

Test	**Subjects with Practical**	**Subjects without Practical**	**Subjects without Theory**
First test	10	20	20
Mid-Semester	20	30	30
Final theory	30	50	-
Final practical	40	-	50
Total	**100**	**100**	**100**

The question paper model and distribution of marks for Mid Semester examinations is as follows.

First Test (30 minutes duration) (Total Marks: 10)

1. Objective Type	10 out of 12	10 x 0.5 marks	5 Marks
2.Definitions/ Short Concepts	5 out of 7	5 x 1 marks	5 Marks

Mid-semester examination

For Subjects with practical(One hour duration) (Total marks: 20)

1. Objective Type	10 out of 12	10 x 0.5 marks	5 Marks
2.Definitions/ Concepts	5 out of 7	5 x 1 marks	5 Marks
3. Short Notes	2 out of 3	2 x 2 ½ marks	5 Marks
4. Essay Type	1 out of 2	1 x 5 marks	5 Marks

For Subjects without practical (One hour duration) (Total marks: 30)

1. Objective Type	10 out of 12	10 x 0.5	5 Marks
2.Definitions/Concepts	5 out of 7	5 x 1	5 Marks
3. Short Notes	4 out of 5	4 x 2 ½	10 Marks
4. Essay Type	2 out of 3	2 x 5	10 Marks

11.3. **Final examination**

11.3.1.The final theory examination will be of two and a half hours duration and practical examination will be of three hours duration,both conducted separately by the University. The question paper for the theory examination will be set as per Bloom's taxonomy by the concerned course teacher in consultation with the Head of the Department. The final theory and practical examinations will be evaluated by respective course teacher.

11.3.2.The question paper model and distribution of marks for final theory examinations are as follows.

Final theory examination (3 hours duration)

For subjects with practical(Total marks: 30)

1. Definitions	5 out of 7	5 x1 marks	5 marks
2. Short Notes	2 out of 3	2 x2½ marks	5 marks
3. Essay Type	Either or type (one question from each unit)	5 x 4 marks	20 marks

For subjects without practical (Total marks: 50)

1. Definitions	6 out of 8	6 x1 marks	6 marks
2. Short Notes	3 out of 5	3 x 3 marks	9 marks
3. Essay Type	Either or type (one question from each unit)(Atleasttwo questions must represent K6 level of Bloom's taxonomy)	5 x 7 marks	35 marks

11.3.3. Practical Examination

Practical examinations will be conducted in the last practical class. Proper maintenance and regular submission of practical records are required. Those who do not bring with them the certified practical records/ specimen collection/ assignments will not be allowed to appear for the practical examination. The marks awarded for specimen collection and assignments shall be noted in the record, at the time of first appearance and will be taken into account for subsequent appearances.

If a student secures a 'pass' in the practical examination of a particular course and fails in the theory examination, then, the practical examination marks obtained in the first attempt will be added to the supplementary examinations also and he/she doesn't require to reappear for practical examination.

Assignment

Each student will be assigned a topic by the concerned course teacher. Such topic should cover a wide range of topics within the subject limits. The topic should be different from that of the credit seminar. Assignments will be evaluated during practical examination.

The distribution of marks for **final practical examination** for courses with theory and practical and only practical is as follows:

S.No.	Particulars	Courses with theory and practical	Courses only with practical
1	Practical part	25	35
2	Assignment/specimen collection	5	5
3	Record	5	5
4	Viva voce	5	5
	Total	**40**	**50**

The pattern of practical part should be uniform in each Department

11.4. GRADING

- The student should secure 60 per cent marks separately in theory and practical and 65 per cent marks in aggregate to secure a pass in the subject. Students who secure marks below 65 per cent in a subject will be treated as Reappearence (RA).
- Each subject shall carry a maximum of 100 marks for purpose of grading. The grading shall be done as grade point, i.e., the percentage of marks earned in a subject is divided by ten. The grade point is expressed on a10 point scale up to two decimals.
- The reappearance examinations for the candidates who fail in a subject or subjects will be held in the subsequent semester.
- Students who did not fulfill the required minimum attendance of **80 per cent** will be awarded 'E' grade and has to repeat the subject.

11.5. Percentage equivalence and Class ranking

In calculation of percentage and class equivalent for OGPA the following formula shall be adopted.

$$\text{Percentage equivalent for OGPA} = \frac{\text{Sum of marks obtained by the candidates in all the Courses}}{\text{Sum of maximum marks in all the Courses}} \times 100$$

In calculation of percentage and class equivalent for OGPA, the following classification shall be adopted.

OGPA	Percentage	**Class**
9.00 and above	90 and above	Distinction
8.00 to 8.99	80.00 to 89.99	I Class
7.00 to 7.99	70.00 to 79.99	II Class
6.50 to 6.99	65.00 to 69.99	Pass

12. Credit Seminar

Seminar is compulsory for all the students and each student should present a seminar of 0+1 credit in the third semester.

12.1.The seminar topic should be only from the major field and should not be related to the area of thesis research.The seminar topics are to be assigned to the students by the Chairman of the Advisory Committee in consultation with the Head of the Department concerned within 2 weeks after the commencement of the semester.

12.2. Under the guidance and supervision of the Chairman of the Advisory Committee, the student will prepare the seminar paper after reviewing all the available literature and present the seminar 2 weeks after completion of Mid-Semester Examination in the presence of the Head of the Department, Advisory Committee, staff members and PG students.

12.3. The circular on the seminars by the post-graduate students shall be sent to other Departments to enable those interested to attend the same.

12.4. The Chairman will monitor the progress of the preparation of the seminar paper and correct the manuscript containing not less than 25 typed/printed pages with a minimum number of 50 references covering the recent 10 years' time. The student will submit 2 copies of the corrected manuscript to the Head of the Department concerned through the Chairman before presentation.

The student will incorporate suggestions and carry out corrections made during the presentation and resubmit three fair copies to the Head of the Department concerned through the Chairman (one copy each to Dept. Library, Chairman and the student) within 10 days after presentation.

12.5.The performance of the student has to be evaluated for 100 marks and Grade Point will be awarded by Advisory Committee. The Grade Point may be given based on the following norms.

Coverage of Literature	40
Presentation	30
Use of Audio–Visual Aids	10
Capacity to Participate in the discussion and answer the Questions	20
Total	**100**

13. Absence of advisory committee member during final viva-voce examination:

13.1 Conducting final viva voce examination in the absence of advisory committee members is not allowed.

13.2. Under extra-ordinary circumstances if the final viva-voce examination to postgraduate student has to be conducted in the absence of one or two advisory committee members, permission to conduct the examination by co-opting another

member in such contingencies should be obtained from the Dean in advance through the Head of the Department. The Chairman of the advisory committee in consultation with the concerned member and Head of the Department will co-opt another member.

13.3. The co-opted member should be from the same department of the member who is not attending the examinations.

13.4. In the absence of the Chairman of advisory committee, respective Heads of Departments should act as Co-chairman with prior permission of Dean.

14. Research Work

14.1. The topic of thesis research to be carried out by the student will be assigned by the Chairman of the Advisory Committee in consultation with the Head of the Department concerned. After assigning the topic, each student may be instructed to submit a detailed programme of work to be carried out by him/her during the semester in the prescribed proforma. After scrutiny and approval, a copy of the programme may be given to the student for carrying out the work during the semester in the prescribed proforma. The evaluation of research work done by the student should be based on the approved programme.

14.2. The distribution of research credits will be as follows:

I Semester	0+ 2
II Semester	0+ 6
III Semester	0+ 10
IV Semester	0+ 12*
Total	0 + 30

(* In the fourth semester, out of 12 credits, 8 credits will be for evaluation of research and remaining 4 credits for evaluation of viva voce)

15. Evaluation of Thesis Research

15.1. Attendance register must be maintained in the department by HOD /major adviser for all the students to monitor whether the student has 80% of attendance in research.

15.2. The student has to submit his/her research observation note book to the major Adviser.The major Adviser will scrutinize the progress and sign the note book with remarks as frequently as possible. This note book will form the basis for evaluation of research progress.

15.3. After completion of 80% attendance for research and on or before the last day of the semester, the advisory committee should evaluate the progress of research work as per the approved programme and monitoring register and award **SATISFACTORY OR UNSATISFACTORY** depending upon quantity and quality of work done by the student during the semester.

15.4.The procedure of evaluating research credits under different situations are explained hereunder.

Situation - I

The student has completed the research credits as per the approved program and awarded **'SATISFACTORY'** by the advisory committee. Under the said situation, the student can be permitted to register fresh credits in the subsequent semester. If the student is awarded **'UNSATISFACTORY',** he/she has to register afresh the same block of the research credits in the subsequent semester.

Situation - II

The student who does not satisfy the required **80 per cent** attendance shall be awarded grade **'E'**.

Situation-III

The student who could not complete the research work as per the approved programme of work for reasons beyond his/her control such as

- Failure of crop
- Non-Incidence of pests or diseases or lack of such experimental conditions
- Non-availability of treatment materials like planting materials chemicals etc.
- Any other impeding/ unfavourable situation for satisfying the advisory committee
- Under the situations II&III, grade 'E' should be awarded. The student has to re-register the same block of research credits for which 'E' grade was awarded in the following semester. The student should not be allowed to register for fresh (first time) research credits.
- In the mark sheet, it should be mentioned that 'E' grade was awarded due to lack of attendance or want for favourable conditions.

Situation – IV

The student who fails to complete the research work after repeating the registration forthe second time will be awarded '**Unsatisfactory'**.

- For the registration of research credits for the third time, permission has to be obtained from the Dean of the Faculty and permission for further registration for the fourth time has to be obtained from the University.
- Re-registration of further research credits shall be decided by the University based on the recommendation of the Advisory Committee, Head of the Department concerned and the Dean, Faculty of Agriculture.

16. Submission of Thesis

16.1.The thesis for his/her Master's degree should be of such a nature as to indicate a student's potentialities for conduct of independent research. The thesis shall be on topic falling within the field of the major subject and shall be the result of the

student's own work. A certificate to this effect duly endorsed by the Major Adviser (Chairman) shall accompany the thesis.

16.2.The research credits registered in the last semester of post graduate programmes should be evaluated only at the time of the submission of thesis, by the advisory committee. Students can submit the thesis at the end of the final semester. If a post graduate student has completed the thesis before the closure of the final semester, the chairman can convene the advisory committee meeting and take decision on the submission of thesis provided the student satisfies 80 per cent attendance requirement. Two copies of the thesis should be submitted in paper pack for evaluation to the HOD.

16.3.The thesis shall contain a certificate from the supervisor specifying that the thesis submitted is a record of research work done by the candidate during the period of study under him/her, and that the thesis has not previously formed the basis for the award of any Degree, Diploma, Associateship, Fellowship or similar title. A statement from the supervisor indicating the extent to which the thesis represents independent work on the part of the candidate should also be made including free fromplagiarism **above the specified level.**

16.4.Thethesis shall also contain a declaration by the candidate that the work reported in the thesis has been carried out by the candidate himself/herself and that the material from other sources, if any, is dulyacknowledgedandnopartofthethesisisplagiarized **more than 25 %.**

17. Grace period

17.1.Students can avail a grace period up to a month for submission of thesis/project report after the closure of final semester by paying necessary fine as prescribed by the University. If a student is not able to submit the thesis within a month (grace period), the student has to re-register the credits in the forthcoming semester.The student who re-register the credits after availing the grace period will not be permitted to avail grace period.

17.2.Based on the recommendation of advisory committee and the Head of the Department, the Dean, can sanction the grace period. A copy of the permission letter along with the receipt for payment of fine as prescribed by the University should accompany the thesis while submission.

18. Submission of thesis after re-registration

The minimum of 80 per cent attendance requirement for submitting the thesis after, re-registration need not be insisted for those students who have fulfilled the minimum academic and residential requirement i.e. 2 years (4 semesters) and completed the minimum credit requirements for getting Degree.

19. Publication of articles

Part of the thesis may also be published in advance with the permission of the HOD. If any part is published, the fact should be indicated in the certificate given by the chairman that the work has been published in part/full in the scientific or popular journals, proceedings, etc. The copies are to be enclosed in the thesis at the time of submission.

20. Evaluation of Thesis

20.1. The thesis submitted in partial fulfillment of a Master's degree shall be evaluated by an external examiner. The external examiner shall be a specialist in the student's major field of study from outside Annamalai University and shall be appointed by the University as per the recommendation of the Head of the Department.

20.2. The external examiner will send the evaluation report in duplicate, one marked to the Controller of Examinations and another to the Head of the Department along with the corrected copy of the thesis. If the report is favourable, Viva-Voce will be arranged by the Head of the Department concerned and conducted by the Advisory Committee along with the external examiner. The chairman of the advisory committee shall send the recommendations of the examining committee to the Controller of Examinations through Head of the Department after the student duly carries out the corrections/ suggestions mentioned by the external examiner (a certificate to be enclosed along with the recommendation). On the unanimous recommendation of the committee and with the approval of the University, the degree shall be awarded to the candidate.

20.3. In case of rejection of the thesis by the external examiner, the Head of the Department concerned and Advisory Committee shall refer the thesis for evaluation by a second external examiner. If the second external examiner recommends the thesis for acceptance, Viva-Voce will be conducted.

20.4. If the revision of the thesis is recommended for repeating experiments, field trial etc., resubmission must be done by the candidate concerned after a minimum of six months. The revised version should be sent to the examiner who recommended revision.

20.5. After incorporating the suggestions of the examiners and those received at the time of viva-voce, three hard bound copies of thesis should be submitted to the Department (one to the scholar, one to the chairperson and one to the Department Library) and one soft copy in CD to the Department. Along with two copies of the thesis, two copies of abstract of thesis (in 10-15 lines) and summary of the findings both in Tamil and English and soft copy both in a C.D. shall be submitted.At the time of final submission, the Chairman of the advisory committee should certify that the corrections and suggestions have been carried out as indicated by the examiners.

21. Revision of thesis

If an examiner recommends for revision of thesis, the following norms will be adopted.

21.1. For revision of draft, the thesis should be resubmitted after a minimum of one month from the date of communication from the Controller of Examinations

21.2. At the time of submission, the advisory committee should give certificate for carrying out the corrections/recommendations. The resubmitted copies of thesis should be got corrected after carrying out the necessary corrections indicated by the external examiner and necessary certificates shall be obtained from the chairman and HOD before the conduct of the final viva-voce.

21.3. A fine prescribed by the University to be collected from the students at the time of resubmission of thesis.

22. Failure to appear for final Viva-voce/ Non submission of thesis after viva-voce.

22.1. If a candidate fails to appear before the examining committee for final viva-voce, on the date fixed by the HOD, the following are the time frame and penalty.

22.2. The re-viva-voce must be completed within two years. An amount of fine prescribed by the University must be charged to the candidate.

22.3. After successful completion of thesis final viva-voce, if a student fails to submit the corrected version of the thesis within 15 days, he/she will be levied a fine prescribed by the University at the time of sending the proposal for result declaration.

23. Internship during Masters Programme

Internship for Development of Entrepreneurship in Agriculture (IDEA)

Currently, a provision of 30 credits for dissertation work in M.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 be benefitted through this process. This pragmatic approach would definitely result in enhancedpartnerships 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 Adviser 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 and10 for writing the report followed by viva-voce, similar to thesis research
- 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

24. Result notification

24.1.After the completion of each semester, the student will be given the statement of marks by the Controller of Examinations.

24.2.The transcript will be prepared by Controller of Examinations. The various subjects taken by a student along with the credits and the grade obtained shall be shown on his/her transcript. Based on the total credits admitted, the final Grade Point Average shall be calculated and given.

25. Award of Medals

Medal should be awarded only if the student is a rank holder and secures at least 8.5 OGPA, clears all courses in first attempt and in the programme having a batch of at least three students.

26. Transitory Regulations

Separate time table of course work under old semester system will be arranged by the HOD. for students with attendance deficiency in a course/courses provided such course/courses are not currently offered due to the introduction of the revised syllabi with effect from the academic year 2022 – 2023. The candidates under old semester system will, however, complete all the examinations within a period of four academic years from the year of admission.

27. Removal of difficulties

If any difficulty arises in giving effect to the provisions of these regulations, based on the recommendations of the Dean, the Vice-Chancellor may issue necessary orders, which appear to him to be necessary or expedient for removing the difficulty.

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GENT 21M.Sc. (Ag.) ENTOMOLOGY

Courses with Credit

I) Course work	Credit
Major Courses	**20**
Minor Courses	**08**
Supporting Courses	**06**
Common Courses	**05**
Seminar	**01**
II) Thesis Research / IDEA	**30**
Total credits	**70**

Distribution Pattern of Courses and Credit (Research)

Semester	Major Courses	Minor Courses	Supporting Courses	Common Courses	Seminar	Research	Credit
I	8	-	6	2	-	2	18
II	12	-	-	2	-	6	20
III	-	6	-	1	1	10	18
IV	-	2	-	-	-	12	14
Credit Load	**20**	**8**	**6**	**5**	**1**	**30**	**70**

Distribution Pattern of Courses and Credit (IDEA)

Semester	Major Courses	Minor Courses	Supporting Courses	Common Courses	Seminar	IDEA	Credit
I	8	-	6	2	-	-	16
II	12	-	-	2	-	-	14
III	-	6	-	1	1	10	18
IV	-	2	-	-	-	10 +10	22
Credit Load	**20**	**8**	**6**	**5**	**1**	**30**	**70**

For MBA (Agri-Business Management)

Distribution Pattern of Courses and Credit (Project work)

Semester	Major Courses	Minor Courses	Supporting Courses	Common Courses	Seminar	Internship	Project	Credit
I	8	-	6	2	-	4	1	16
II	12	-	-	2	-	6	2	14
III	-	6	-	1	1	-	7	18
IV	-	2	-	-	-	-	10	22
Credit Load	**20**	**8**	**6**	**5**	**1**	**10**	**20**	**70**

Distribution Pattern of Courses and Credit

S.no.	Course Code	Course Title	Credit
		Compulsory Major Courses	
1	ENT 501	Insect Morphology and Taxonomy	3 (2+1)
2	ENT 502	Insect Anatomy and Physiology	3 (2+1)
3	ENT 506	Toxicology of Insecticides	3 (2+1)
4	ENT 509	Pests of Field, Horticultural and Plantation Crops	3 (2+1)
		Optional Major Courses	
5	ENT 504	Insect Ecology	2 (2+0)
6	ENT 505	Biological Control of Insect Pests and Weeds	2 (1+1)
7	ENT 507	Host Plant Resistance	2 (1+1)
8	ENT 508	Concepts of Integrated Pest Management	2 (2+0)
9	ENT 511	Post Harvest Entomology	2 (1+1)
10	ENT 518	Lac Culture	2 (2+0)
11	ENT 519	Molecular Approaches in Entomology	2 (1+1)
12	ENT 520	Plant Quarantine, Biosafety and Biosecurity	2 (2+0)
13	ENT 521	Edible and Therapeutic Insects	2 (1+1)
14	ENT 522	Medical and Veterinary Entomology	2 (1+1)
15	ENT 523	Forest Entomology	2 (2+0)
		Minor Courses	
16	ENT 512	Insect Vectors of Plant Pathogens	2 (1+1)
17	ENT 513	Principles of Acarology	2 (1+1)
18	ENT 514	Vertebrate Pest Management	2 (1+1)
19	ENT 515	Techniques in Plant Protection	3 (1+2)
20	ENT 516	Apiculture	3 (1+2)
21	ENT 517	Sericulture	3 (1+2)
		Supporting Courses	
22	PGS 501	Library and Information Services	1 (0+1)
23	PGS 502	Technical Writing and Communications Skills	1 (0+1)
24	PGS 503	Intellectual Property and its Management in Agriculture	1 (1+0)
25	PGS 504	Basic Concepts in Laboratory Techniques	1 (0+1)
26	PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1 (1+0)
27		Non Gradial Courses	
	NGC 511	Disaster Management (1+ 0)	-
	NGC 512	Constitution of India (1+ 0)	-
28	VAC	Value added course	-
29	ENT 591	**Master's Seminar**	1 (0+1)
30	ENT 596/597/598/599	**Research / IDEA**	30

Programme Outcome (PO)
1. Graduate will acquire comprehensive knowledge on basic concepts and current developments in insect science
2. Graduates will be mastering skills in advanced studies on various aspects of entomology
3. Graduates will have expertise in analysingissues and problems in managing insects
4. Graduate will be able to develop skills on experimental tools related to entomology
5. Graduates will be able to identify the research gaps, design and execute research project and suggest measures to solve.

PO and CO Mapping Matrix

AFFINITY LEVEL	
1	**Low**
2	**Moderate/ Medium**
3	**Substantial /High**

SEMESTER-WISE DISTRIBUTION OF COURSES (RESEARCH)

Sl. No.	Course Title	Credit
	I Semester	
1.	Major Courses	8
2.	Supporting Courses	
	STA501 - Statistical Methods for Applied Sciences	3
	COM 501 - Information Technology in Agriculture	3
3.	Common Courses	
	PGS 501 - Agricultural research, research ethics and rural development programmes	1
	PGS 502 - Technical writing and communications skills	1
4.	**ENT 596 Research**	2
	Total	**18**
	II Semester	
1.	Major Courses	12
2.	Common Courses	
	PGS 503 - Basic Concepts In Laboratory Techniques	1
	PGS 504 - Library and information services	1
3.	**ENT 597 Research**	6
	Total	**20**
	III Semester	
1.	Minor courses	6
2.	Common course	
	PGS 505 - Intellectual property and its management in agriculture	1
3.	NGC 511 - Disaster Management (Contact hour 1+ 0)	-
4.	NGC 512 - Constitution of India (Contact hour 1+ 0)	-
5.	**ENT 591 Master's Seminar**	1
6.	**ENT 598 Research**	10
7.	Value Added Course (Contact hour 3+0) **(**https://annamalaiuniversity.ac.in/studport/value_added_crs.php)	-
		18
	IV Semester	
1.	Minor course	2
2.	**ENT 599 Research**	12 (8+4)
		14

SEMESTER-WISE DISTRIBUTION OF COURSES (IDEA)

Sl. No.	Course Title	Credits
	I Semester	
1.	Major Courses	8
2.	Supporting Courses	
	STA501 - Statistical Methods for Applied Sciences	3
	COM 501 - Information Technology in Agriculture	3
3.	Common Courses	
	PGS 501 - Agricultural research, research ethics and rural development programmes	1
	PGS 502 - Technical writing and communications skills	1
	Total	**16**
	II Semester	
1.	Major Courses	12
2.	Common Courses	
	PGS 503 - Basic Concepts In Laboratory Techniques	1
	PGS 504 - Library and information services	1
	Total	**14**
	III Semester	
1.	Minor courses	6
2.	Common course	
	PGS 505 - Intellectual property and its management in agriculture	1
3.	Disaster Management (Contact hour 1+ 0)	-
4.	Constitution of India (Contact hour 1+ 0)	-
5.	**ENT 591 Master's Seminar**	1
6.	**ENT 598 IDEA**	10
7.	Value Added Course (Contact hour 3+0) **(**https://annamalaiuniversity.ac.in/studport/value_added_crs.php)	-
		18
	IV Semester	
1.	Minor course	2
2.	**ENT 599 IDEA**	20 (10+10)
		22

ENT 501 - Insect Morphology and Taxonomy(2+1)

Course objectives

- To have a complete understanding of the comparative morphology of insects that can be utilized in taxonomy, ecology and applied entomology
- To sensitize the students on the theory and practice of classifying organisms (with special reference to animals) and the rules governing the same.
- To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects with an emphasis on the practical aspects.

Theory

Unit I: Insect Body wall, head,thorax and Abdomen

External Morphology -Insect body wall - structure, cuticular outgrowths, colourationand special integumentary structures, body tagmata, sclerites andsegmentation.Head- Origin, tentorium and neck sclerites,structure and modification; mouthparts, antennae, their types and functioning.Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings:structure and modifications, venation, wing coupling apparatus and mechanism offlight; legs: structure and modifications.Abdomen- Segmentation and appendages; genitalia and their modifications;Insect sense organs (mechano-, photo- and chemo-receptors); organogenensisatpupal stage; insect defense; chaetotaxy; morphological traits in relation to forensicentomology.

Unit II:Development &Metamorphosis

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

Unit III:Insect taxonomy and systematics – Basics & Advances

History of insect classification, definition and principles of systematics and its importance. Taxonomic publications, recent micro and macro morphological, embryological, ecological, behavioural, cytological, biochemical and numerical taxonomy. Identification, purpose, methods character matrix, taxonomic keys - preamble - bi and trinomial nomenclature - major group names - validity of names - principle of priority, synonymy and homonymy, type concept. 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. Typological, nominalistic, biological and evolutionary species concepts, Process of speciation and interbreeding allopatric species. Molecular systematics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labelling protocols and procedures.

Unit IV: Classification of non-insect orders, apterygotes and exopterygotes

Recent classification of insects – Diagnosis of non-insect orders – Distinguishing characters, general biology, habits and habitats of insect orders and economically important families

contained in them. Collembola, Protura and Diplura, Apterygotes –Archaeognatha and Zygentoma. Diagnosis of Palaeoptera and Neoptera. Diagnostic characters of orders and important families of Palaeoptera (Ephemeroptera and Odonata) and Neoptera – Plecoptera, Dermaptera, Embioptera, Zoraptera, Orthoptera, Phasmatodea, Grylloblattodea, Mantophasmatodea, Mantodea, Blattodea (roaches and termites), Psocodea (free-living and parasitic), Thysanoptera and Hemiptera.

Unit V: Classification of endopterygotes

Diagnostic characters of various holometabolous insect orders and important families of Neuroptera, Megaloptera, Raphidioptera, Coleoptera, Strepsiptera, Diptera, Mecoptera, Siphonaptera, Trichoptera, Lepidoptera and Hymenoptera. **Current trends in morphology and taxonomy of Insects**

Practical

Preparation of permanent mounts of different body parts and their appendages oftaxonomic importance including male and female genitalia;Dissection of genitalia. Types of immature stages in insects; their collection, rearingand preservation;Identification of immature insects to orders and families, in endopterygoteorders,viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using keys;Methods of collection and preservation of insects - External morphology of insects – detailed observation and naming of parts. Structure and modification of head, antennae and mouth parts. Thoracic sclerites, structure and modification of legs, wings and their venation. Abdomen and its appendages. Genitalia of insects of representative orders and families. Morphological features of insect eggs, larvae, pupae and adults. Chaetotaxy in insects. Micrometry in insects, insect imaging and microphotography. Preparation of permanent slides. Study of insect orders and their identification using taxonomic keys. Observing and keying out orders and families of insects - Collembola, Protura, Diplura, Archaeognatha, Zygentoma, Ephemeroptera, Odonata, Plecoptera, Dermaptera, Embioptera, Orthoptera, Phasmatodea, Mantodea, Blattodea (roaches and termites), Psocodea (free-living and parasitic), Thysanoptera, Hemiptera, Neuroptera, Megaloptera, Raphidioptera, Coleoptera, Strepsiptera, Diptera, Mecoptera, Siphonaptera, Trichoptera, Lepidoptera and Hymenoptera. Field visit to agricultural, horticultural, forest and hill ecosystems to collect insects of different orders.

Assignment:10 permanent slides of appendages in insects – 5 immature stages (wet preservation). Submission of 50 insects representing major families and orders.

Theory Lecture Schedule

1. Introduction to morphology – Importance of insect morphology. Tagmosis in insects.
2. General body wall – its structure, cuticular outgrowths, special integumentary processes.
3. Insect colouration. Body regions, sclerites, sutures and sulci.
4. Insect head and its orientation; appendages of head and their modifications.
5. Mouth parts in insects – external structure - mandibulate types.
6. Mouth parts in insects – external structure - haustellate types.
7. Insect thorax and its appendages - Legs – modifications and types.

8. Insect wings – development – venation – modifications and types -articulation with thoracic muscles.
9. Insect abdomen – segmentation – modifications – appendages in different life stages.
10. Insect genitalia and their modification.
11. Structure of sense organs.
12. Insect metamorphosis – types of insect egg, larva and pupa – Sexual dimorphism polymorphism and polyphenism in insects. Current trends in insect morphology.
13. Insect taxonomy and systematics - definition and principles.
14. Taxonomic publications, recent advances in insect taxonomy - micro and macro morphological, embryological, ecological, behavioural, cytological, biochemical and numerical taxonomy.
15. Typological, nominalistic, biological and evolutionary species concepts.
16. Taxonomic keys.
17. **Mid Semester examination**
18. International Code of Zoological Nomenclature (ICZN) – preamble- bi and trinomial nomenclature.
19. Nomenclature - major group names- validity of names- principle of priority, synonymy and homonymy, type concept.
20. Recent classification of insects.
21. Diagnosis of non-insect orders – Collembola, Protura and Diplura.
22. Apterygotes –Archaeognatha and Zygentoma. Diagnosis of Palaeoptera and Neoptera.
23. Diagnostic characters of orders and important families of Palaeoptera (Ephemeroptera and Odonata).
24. Diagnostic characters of orders and important families of Neoptera – Plecoptera, Dermaptera, Embioptera and Zoraptera.
25. Diagnostic characters of orders and important families of Neoptera –Orthoptera.
26. Diagnostic characters of orders and important families of Neoptera - Phasmatodea, Grylloblattodea and Mantophasmatodea
27. Diagnostic characters of orders and important families of Neoptera - Mantodea, Blattodea (roaches and termites) and Psocodea (free-living and parasitic).
28. Diagnostic characters of orders and important families of Neoptera- Thysanoptera and Hemiptera.
29. Diagnostic characters and important families of orders Neuroptera, Megaloptera and Raphidioptera.
30. Diagnostic characters and important families of order Coleoptera.
31. Diagnostic characters and important families of orders Strepsiptera and Diptera.
32. Diagnostic characters and important families of orders Mecoptera, Siphonaptera and Trichoptera.
33. Diagnostic characters and important families of order Lepidoptera.

34. Diagnostic characters and important families of order Hymenoptera. Current trends in insect taxonomy.

Practical Schedule

1. External features of grasshopper and beetle - detailed observation of tagma in insects - Insect head orientation – Types of insect mouth parts and study of mandibulate and haustellate mouth parts – Types of insect antennae.
2. Observing insect thoracic sclerites – Types of insect legs and modifications – Wing venation, types of wings and wing coupling mechanism in insects.
3. Observing insect abdomen – modifications and appendages. Dissection and observation of genitalia of Orthoptera, Coleoptera, Lepidoptera and Hymenoptera.
4. Examining types of insect eggs, larvae and pupae. Chaetotaxy in insects.
5. Practicing micrometry in insects, insect imaging and microphotography.
6. Preparation of permanent slides of insects and insect parts.
7. Practicing methods of collection and preservation of insects including immature stages.
8. Hands on experience in diagnosing insect orders and their identification using taxonomic keys. Observing and keying out orders - Collembola, Protura, Diplura, Archaeognatha, Zygentoma, Ephemeroptera and Odonata.
9. Observing and keying out orders and families of insects - Plecoptera, Dermaptera, Embioptera, Orthoptera, Phasmatodea and Mantodea.
10. Observing and keying out orders and families of insects - Blattodea (roaches and termites) and Psocodea (free-living and parasitic).
11. Observing and keying out orders and families of insects– Thysanoptera and Hemiptera.
12. Observing and keying out orders and families of insects - Neuroptera, Megaloptera, Raphidioptera, Strepsiptera, Diptera, Mecoptera, Siphonaptera and Trichoptera.
13. Observing and keying out families of insect order Coleoptera.
14. Observing and keying out families of insect order Lepidoptera.
15. Observing and keying out families of insect order Hymenoptera.
16. Field visit to agricultural and horticultural, ecosystems to collect insects of different orders.
17. Field visit to forest and hill ecosystems to collect insects of different orders.

Course outcome

CO1: Knowledge onexternal morphology and metamorphosis of insects.
CO2: Proficiency in micrometry and other laboratory techniques in morphology and taxonomy.
CO3: Expertise inrunning taxonomic keys for identification of insects at family level.
CO4: Skills in identifying diagnostic features of non-insect and insect orders.
CO5: Evaluating the insect species diversity in various ecosystems.

CO –PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	3	3	-
CO 2	2	3	3	2	1
CO 3	3	3	3	2	1
CO 4	1	1	3	3	1
CO 5	1	1	1	3	2

Suggested Reading:

1. Beutel, R.G., F. Friedrich, S.Q. Ge and X.K. Yang. 2014. *Insect Morphology and Phylogeny: A textbook for students of Entomology*. De Gruyter, Berlin. 516 p.
2. Chapman, R.F. 2013. *The Insects: Structure and function*. Cambridge University Press, Edinburgh, Cambridge, UK, 961 p.
3. Gillott C. 1995. *Entomology*, 2nd Ed. Plenum Press, New York, London. 798 p.
4. Gullan, P.J. and P.S. Cranston. 2010. *The Insects- An Outline of Entomology*, Wiley-Blackwell, Sussex, UK. 565 p.
5. Richards, O.W. and R.G. Davies. 2014. *Imms' General Textbook of Entomology*, Volume I & II (10th Edition). Springer, UK. 1354 p.
6. Shaik, J. and K. Rajashekar. 2017. *Guide for Insect Morphology*. Educreation Publishing, New Delhi. 230 p.
7. Snodgrass, R. E. 1993. Principles of Insect Morphology. Cornell University Press, USA. 768 p.
8. Strickland E.H., B. Hocking and G.E. Ball. 2017. *A Laboratory Manual for Insect Morphology*, ReInk Books, S.N. Books world, New Delhi. 94 p.
9. Stehr FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publication, Iowa. 768 p.
10. Triplehorn, C.A. and N.F. Johnson. 2005. *Borror and Delong's Introduction to the Study of Insects*. Thomson, USA, 888 p.

E-Resources

1. http://extension.oregonstate.edu/umatilla/sites/default/files/external_morphology.pdf
2. http://www.zoology.ubc.ca/bclepetal/Order%20Lepidoptera%20et%20al%20Text%20Files/order_lepidoptera.htm
3. http://www.faculty.ucr.edu/~legneref/entomol/exorthop.htm
4. http://www.waterbugkey.vcsu.edu/php/familylist.php?idnum=1&o=coleoptera
5. http://www.knowyourinsects.org/Key%20to%20Insect%20Orders.pdf

ENT 502 - Insect Anatomy and Physiology (2+1)

Course objectives

- To impart knowledge about the anatomy and physiology of insect body systems.

- To gain skills on dissecting out various systems and identifying their anatomical modifications.
- To understand the basic biochemical processes such as cellular metabolism & its significance in energy generation.
- To gain hands on training in various biochemical lab assays.

Theory

Unit I: Insect Embryology and Integument physiology

History, importance and scope of insect physiology; Embryonic development in insects – Formation of different systems. Physiologyandchemistry of integument, physiology of moulting,biosynthesis of chitin.

Unit II: Digestive and excretory physiology

Structure, modification and physiology of digestive system. Energy/ cellular metabolism – Carbohydrate metabolism – Glycolysis, Kreb's cycle, Oxidative phosphorylation. Metabolism of proteins and lipids – Role of fat bodies in metabolism. Structure, modification and physiology of excretory system. Homeostasis – Osmoregulation of water and salts – Excretion in aquatic and endo parasitic insects.

Unit III: Circulatory and respiratory physiology

Structure, modifications and physiology of circulatory system – Haemocytes – Immunity. Structure, modification and physiology of respiratory system – Physiology of gaseous exchange – Respiration in aquatic and parasitic insects – Role of respiration and haemolymph in thermoregulation.

Unit III: Neuro physiology, sense organs and muscles

Structure, modification and physiology of nervous system – Brief overview about ion channels – Neuro transmitters – Bio-chemical mechanism of nerve transmission. Sense organs – Structure and physiology of Photo – Chemo – and Mechano receptors. Sound & light production in insects. Basic structure and physiology of muscles.

Unit IV: Insect endocrinology and reproductive physiology

Endocrine glands – Structure, secretions – Brief overview about synthesis and functions of Prothoracicotropic hormone(PTTH), ecdysteroids, juvenile hormones, eclosion hormones and other minor hormones. Structure and modification of reproductive system – Physiology of vitellogenesis, oogenesis and spermatogenesis – Different types of reproduction.

Unit V: Nutritional physiology

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. **Current trends in insect physiology and nutrition.**

Practical

Study of anatomy of different systems of grasshopper, cockroach and blister beetle. Latest analytical techniques for analysis of free amino acids of haemolymph; Determination of chitin in insect cuticle; Estimation of reducing sugar, proteins and lipids in insect tissue homogenates. Examination and count of insect haemocytes; Chromatographic analysis of free amino acids in haemolymph. Estimation of acetyl choline and cholinesterase activity in insects. Determination of respiratory quotient. Studying endo symbionts in insects. Preparation and evaluation of various diets; Assessment of feeding efficiency and utilization

of natural and artificial diet by insects. Identification and estimation of haemocytes – Microtomy.

Theory Lecture Schedule

1. History, importance and scope of insect physiology.
2. Embryonic development in insects.
3. Formation of different systems.
4. Physiologyandchemistry of integument, physiology of moulting, biosynthesis of chitin.
5. Structure,modifications and physiology of digestive system.
6. Energy/ cellular metabolism. Carbohydrate metabolism – Glycolysis, Kreb's cycle, Oxidative phosphorylation. Metabolism of proteins and lipids – Role of fat bodies in metabolism.
7. Structure, modification and physiology of excretory system.
8. Homeostasis – Osmoregulation of water and salts – Excretion in aquatic andendoparasitic insects.
9. Structure, modifications and physiology of circulatory system.
10. Haemolymph and types of haemocytes. Physiological role of haemocytes and immunity.
11. Structure, modification and physiology of respiratory system.
12. Physiology of gaseous exchange.
13. Respiration in aquatic and parasitic insects.
14. Role of respiration and haemolymph in thermoregulation.
15. Structure of nervous system.
16. Physiology and modifications of nervous system – Brief overview about Ion channels, and axonic conduction. Neuro transmitters, Bio-chemical mechanism of nerve transmission – Synaptic conduction.
17. **Mid semester examination**
18. Sense organs – Structure and physiology of Photoreceptors.
19. Structure and physiology of Chemoreceptors.
20. Structure and physiology of Mechanoreceptors.
21. Sound & light production in insects.
22. Basic structure and physiology of muscles.
23. Endocrine glands – Structure and secretions.
24. Brief overview about synthesis and functions of Prothoracicotropic hormone (PTTH), ecdysteroids, juvenile hormones, eclosion hormones.
25. Brief overview about synthesis and functions of other minor hormones – PBANS, diuretic hormones etc.
26. Structure and modification of reproductive system.
27. Physiology of vitellogenesis and oogenesis.
28. Physiology of spermatogenesis.
29. Different types of reproduction.

30. Insect nutrition – Role of carbohydrates, proteins and lipids in growth and development of insects.
31. Role of vitamins and minerals in growth and development of insects.
32. Role of sterols in growth and development of insects.
33. Role of extra and intra cellular microorganisms in nutrition.
34. Artificial diets and insect nutrition. Current trends in insect physiology and nutrition.

Practical Schedule

1. Dissection of cockroach / grasshopper / blister beetle to study anatomy of digestive system.
2. Dissection of silk cotton bug to study filter chamber.
3. Dissection of cockroach / grasshopper / blister beetle to study anatomy of reproductive system.
4. Dissection of cockroach / grasshopper / blister beetle to study anatomy of nervous system. Observing ventral nerve cord and ganglia.
5. Dissection of cockroach / grasshopper / blister beetle to study anatomy of circulatory system. Studying heart beat in lepidopteran caterpillar.
6. Dissection of cockroach / grasshopper / blister beetle to study anatomy of respiratory system. Observing trachea, tracheoles and taenidial lining.
7. Estimation of reducing sugars in insect homogenates by DNS method.
8. Estimation of protein in insect homogenates by Lowry's method.
9. Estimation of lipids in insect homogenates by Bligh – Dyer method.
10. Paper chromatographic analysis of free Amino acids in haemolymph.
11. Thin layer chromatographic analysis of free Amino acids in haemolymph.
12. Estimation of acetyl choline and cholinesterase activity in insects.
13. Determination of respiratory quotient.
14. Studying endosymbionts in insects.
15. Comparison of feeding efficiency and utilization of artificial and natural diet by insects.
16. Identification and estimation of haemocytes.
17. Practicing microtomy.

Course Outcome

CO1: Expertise in insect embryologyand post-embryonic growth in insects.
CO2: Proficiency in structure, modification and physiology of various systems in insects.
CO3: Capable of understanding ion channels and nerve physiology.
CO4: Knowledge on the role of various sense organs in insects and their function.
CO5: Proficiency in energy metabolism, Homeostasis and thermoregulation in insects.

CO – PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	2	1	1
CO 2	3	3	2	1	1
CO 3	3	3	2	2	1

CO 4	3	3	2	2	1
CO 5	3	3	2	1	1

Suggested Reading:

1. Chapman, R.F. 2012. *The Insects: Structure and Function*, Cambridge UniversityPress, UK, 788 p.
2. Chapman, R.F., A.E. Douglas and S.J. Simpson. 2013. *The Insects: Structure and Function*, 5th Edition, Cambridge University Press, 929 p.
3. Chitra, K.C. 2016. *A Textbook of Insect Physiology*, Second Edition, KalyaniPublishers, New Delhi, 218 p.
4. Gullan, P. J. and P.S. Cranston. 2010. *The Insects - An Outline of Entomology*, Fourth Edition, Wiley – Blackwell Publishers, Oxford, 624 p.
5. Kerkut, G. A. and L.I. Gilbert. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*, 13 Volumes, Pergamon Press, Oxford.
6. Klowden, M.J.2013. *Physiological Systems in Insects*, Third Edition, Elsevier Inc., Netherlands, 696 p.
7. Nation, J. L. 2015. *Insect Physiology and Biochemistry*, Third Edition, CRC Press, New York, 644 p.
8. Novak, V.J. A. 1975. *Insect Hormones*, Second Revised edition, Chapman and Hall, London, 600 p.
9. Rockstein, M. 1974. *The Physiology of Insecta*, Second Edition, Elsevier Inc, 588 p.
10. Wigglesworth, V. B. 1972. *The Principles of Insect Physiology*, Springer,Netherlands. 827 p.

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1. http://krishikosh.egranth.ac.in/handle/1/2049010
2. file:///E:/967361.pdf
3. file:///E:/2010-0012_rovarfiziologia_eng.pdf
4. http://www.phthiraptera.info/Publications/47192.pdf
5. http://www.tandfonline.com/doi/pdf/10.4161/cib.23804

ENT 506 - Toxicology of Insecticides (2+1)

Course Objectives

- To understand basic concepts of toxicology and to study about chemistry and mode of action of insecticides.
- To understand bioassay techniques
- To know about the formulation types
- To know the techniques to overcome the residue and resistance problems

Theory

Unit I: Principles of Toxicology

Toxicology – Definition, Principles, branches and scope of insecticide toxicology; history - toxicology, chemical control, pesticide use and pesticide industry in India.Toxicity evaluation – dose – response relationship – NOEL, LOEL – Median lethality concept – Toxicity parameters.

Unit II: Classification and chemistry of insecticides

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature;IRAC-– toxicity range – chemical classification. Categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general; Chemistry and important characteristics of major groups of insecticides viz., inorganic, organic and synthetic organics. Bio-rationals – antifeedants, repellants, chemosterilants, IGRs, pheromones and neuropeptides. Rodenticides, acaricides and nematicides. New promising compounds/ new insecticide molecules; nanopesticides.

Unit III: Mode of action of insecticides and rodenticides

Mode of action of major groups of insecticides *viz.,* inorganic, organic and synthetic organics. Brief overview on structure – activity relationship.Joint-action of insecticides-synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity, phytotoxicity and shelf life. bioassay definition, objectives, criteria, factors, problems and solutions.

Unit IV: Insecticide metabolism and consequences of insecticide usage

Metabolism of insecticides - Phase I and II reactions in mammals. Consequences of insecticides usage – Insecticide resistance – Types – Molecular mechanisms– Insecticide resistance management. Pest resurgence. Insecticide residues – Hazards to human, animals, pollinators and wildlife – Concepts in relation to residues – ADI, MRL, waiting period – Principles and methods of residue analysis.

Unit V: Development of insecticides

Insecticide development. Insecticide Act 1968 and Rules 1971 and amendments – Registration of insecticides – Procedure and data requirement. label claim, and quality control of insecticides, Basic toxicological assessment procedures – acute oral, dermal, inhalation toxicities – Ethics in animal use; safe use of insecticides; diagnosis and treatment of insecticide poisoning.**Current trends in insecticide Toxicology**

Practical

Rearing of test insects – various bioassay techniques – determination of LC_{50} and LD_{50} of insecticides – bracketing – Probit analysis – graphical method and Finney's method – Green house evaluation of insecticides – principles of field evaluation of insecticides – Physical properties of various formulations of insecticides. Carriers and adjuvants in insecticide formulations. Pesticide appliances Determination of synergistic activity – determination of resistance ratio, susceptibility index – determination of diagnostic dose – studies on compatibility and phytotoxicity of insecticides – safety evaluation of insecticides towards natural enemies and pollinators – pesticide residue analysis. Visit to pesticide residue analysis lab or toxicological evaluation centres

Lecture Schedule

1. Toxicology – Definition, Principles, branches and scope of insecticide toxicology; history - toxicology, chemical control.
2. Pesticide use and pesticide industry in India.
3. Toxicity evaluation – dose – response relationship – NOEL, LOEL – Median lethality concept – Toxicity parameters.
4. Classification of insecticides and acaricides based on mode of entry and mode of action.
5. Classification of insecticides and acaricides based on chemical nature.
6. IRAC-– toxicity range – chemical classification. categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general.
7. Chemistry and important characteristics of major groups of inorganic insecticides.
8. Chemistry and important characteristics of major groups of organic insecticides.
9. Chemistry and important characteristics of major groups of synthetic organic insecticides.
10. Biorationals – antifeedants, repellants, chemosterilants, IGRs, pheromones and neuropeptides. Rodenticides, acaricides and nematicides.
11. New promising compounds/ new insecticide molecules; nanopesticides.
12. Mode of action of major groups of inorganic insecticides.
13. Mode of action of major groups of organic insecticides.
14. Mode of action of major groups of synthetic organicinsecticides.
15. Brief overview on structure – activity relationship.
16. Joint action of insecticides- synergism, potentiation and antagonism.
17. **Mid Semester Examination**

18. factors affecting toxicity of insecticides; insecticide compatibility, selectivity, phytotoxicity and shelf life.
19. Bioassay - definition, objectives, criteria, factors, problems and solutions.
20. Metabolism of insecticides - Phase I and II reactions in mammals.
21. Consequences of insecticides usage – Insecticide resistance – Types – Molecular mechanisms.
22. Insecticide resistance management.
23. Pest resurgence.
24. Insecticide residues – Hazards to human, animals, pollinators and wildlife.
25. Concepts in relation to residues – ADI, MRL, waiting period.
26. Principles and methods of residue analysis.
27. Insecticide development.
28. Insecticide Act 1968 and Rules 1971 and amendments.
29. Registration of insecticides – Procedure and data requirement. Label claim.
30. Quality control of insecticides.
31. Basic toxicological assessment procedures – acute oral, dermal, inhalation toxicities.
32. Ethics in animal use.
33. Safe use of insecticides; diagnosis and treatment of insecticide poisoning.
34. Current trends in insecticide Toxicology

PRACTICAL SCHEDULE

1. Mass culturing of test insects – Pulse beetle, *Spodoptera* and Aphids.
2. Practicing various bioassay techniques.
3. Preparation of test solutions for bio assays. Determination of LC_{50} and LD_{50} of insecticides and bracketing.
4. Probit analysis – graphical method and Finney's method.
5. Practicing greenhouse evaluation of insecticide.
6. Learning principles of field evaluation of insecticides.
7. Studying the properties of various formulations of insecticides.
8. Carriers and adjuvants in insecticide formulations.
9. Determination of synergistic activity.
10. Determination of resistance ratio, susceptibility index.
11. Determination of diagnostic dose.
12. Studies on compatibility assessment of insecticides with other agrochemicals.
13. Phytotoxicity assessment of insecticides.
14. Safety evaluation of insecticides towards natural enemies and pollinators.
15. Pesticide residue analysis in various matrices (plant, soil and water).
16. Learning basic toxicological assessment procedures such as acute, oral and dermal toxicities.
17. Visit to pesticide residue analysis lab and toxicological evaluation centers.

Course Outcome

CO1: Knowledge on the response of animals/insects to insecticides and itsmeasurement.
CO2: Familiarity with different types of pesticide classifications and their chemistry.
CO3: Knowing the target sites of pesticides and their actions.
CO4: Understanding the degradation of insecticides in environment.
CO5: Knowledge on Regulations regarding insecticides.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	1	3	3
CO 2	3	3	1	2	3
CO 3	3	3	1	3	3
CO 4	3	3	1	3	3
CO 5	3	3	1	3	3

Suggested Reading:

1. Copping, L. G. and H.G. Hewitt. 1998. *Chemistry and Mode of Action of Crop Protection Agents*. The Royal Society of Chemistry, London. 145 p.
2. Gupta, HCL, 2001. *Insecticides Toxicology and Uses*, Agrotech Publishing Academy, New Delhi, 478 p.
3. Ishaaya, I. and D. Degheele. 1998. *Insecticides with Novel Modes of Action: Mechanisms and Application*, Springer and Verlag Berlin, 289 p.
4. Ishaaya, I., R. Nauen and A.R. Horowitz. 2007. *Insecticides Design Using Advanced Technologies*, Springer and Verlag, Berlin, 305 p.
5. Kranthi, K.R. 2005. *Insecticide Resistance -Monitoring, Mechanisms and Management Manual*. CICR, Nagpur, 153 p.
6. Matsumura, F. 1985. *Toxicology of Insecticides*. Plenum Press, New York. 502 p.
7. Perry, A.S., I. Yamamoto, I. Ishaaya and R. Perry. 1998. *Insecticides in Agriculture and Environment*: *Retrospects and prospects*. Springer and Verlag, New York, 261 p.
8. Regupathy, A. and K.P. Dhamu. 2003. *Statistics work book for insecticide toxicology*. Suriya Desktop Publishers, Coimbatore, 177 p.
9. Singh, D.K. 2012. *Pesticide Chemistry and Toxicology,Volume 1, Toxicology: Agriculture and Environment*, Bentham Science Publishers, UAE, 142 p.
10. Yu, S. J. 2014. *The Toxicology and Biochemistry of Insecticides*, Second Edition, CRC Press, New York. 380 p.

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1. http://nsdl.niscair.res.in/jspui/handle/123456789/226
2. http://www.fssai.gov.in/dam/jcr:34b311bb-4141-4a41-ad92-65e9258c2bc5/Manual_Pesticides_Residues_09_01_2017.pdf
3. http://www.irac-online.org/
4. https://pdfs.semanticscholar.org/a81f/1625f186ecaf990bd7e1452a290a98e6feb0.pdf
5. R. Bloomquist, Jeffrey. (1996). Ion Channels as Targets for Insecticides. Annual review of entomology. 41. 163-90. 10.1146/annurev.en.41.010196.001115

ENT 509 –Pestsof Field, Horticultural and Plantation Crops(2+1)

Course Objectives

- To familiarize the students about nature of damage and seasonal incidence of pestiferous insects that cause loss to major field, horticultural and plantation crops
- To gain knowledge on the latest strategies in integrated management of these pests

Theory

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

Unit I: Pests of cereals, millets and pulses

Cereals: Rice, Wheat and Maize; Millets; Pulses: Red gram, Black gram, Green gram, Bengal gram, Cowpea, Pea, Lab lab and Soybean.

Unit II: Pests of oilseeds, fibre and sugar crops, masticatories, green manures and forage crops

Oil seeds: Groundnut, Sesame, Sunflower, Safflower, Castor and Mustard; Fibre Crops: Cotton and Jute; Sugar Crops: Sugarcane and Sugarbeet; Masticatories: Tobacco, Arecanut and Betelvine; Green manures and Forage crops.

Unit III: Pests of vegetables, tubers, spices and condiments, plantation and beverage crops

Vegetables: Brinjal, Bhendi, Tomato, Crucifers, Cucurbits, Moringa and Amaranthus; Tuber crops: Potato, Sweet potato, Tapioca and Yam; Spices and Condiments: Pepper, Cardamom, Cinnamon, Chillies, Onion, Garlic, Ginger, Turmeric, Coriander, Curry leaf, Tamarind and Mint; Plantation crops: Coconut, Oil palm; Beverage crops: Coffee, Tea and Cocoa.

Unit IV: Pests of fruits and flowers

Tropical fruits: Mango, Sapota, Citrus, Banana, Grapevine, Guava, Cashew, Jack, Pomegranate, Pineapple, Papaya, Ber; Temperate fruits: Apple, Plum, Peach and others; Flower crops: Rose, Jasmine, Chrysanthemum, Crossandra, Tube rose, Marigold and Nerium.

Unit V: Pests of tree, lawn, ornamental and medicinal plants, mushroom, green house crops, locusts, non-insect pests and insect vectors of plant diseases

Tree Crops: Neem, Teak, Sandalwood, Eucalyptus, Casuarina; Pests of Lawn; Ornamental crops: Crotons, Gladiolus, Gerbera, Lily and Carnation; Medicinal plants: Ocimum, Senna, Periwinkle, Glory lily, Ashwagandha, Aloe and Noni; Mushroom pests; Green house pests; Non-insect pests: Rodents, mites, nematodes and birds; Polyphagous pests - Locusts; Insect vectors of plant diseases – Major groups and major diseases transmitted by them. Insect pest scenario in relation to climate change.**Current trends in crop pests and their management.**

PRACTICAL

Field visits, collection and Identification of symptoms of damage and life stages of important pests of different field and horticultural crops - Cereals, Millets, Pulses, Oilseeds, Fibre, Sugarcane, Masticatories, Green Manures, Forage Crops, Vegetables, Tubers, Spices and Condiments, Plantations, Beverages, Fruits, Flowers, Ornamental, Medicinal Plants, Tree,

Lawn, Mushroom, Green house crops, Non-insect pests, Locusts, Insect Vectors of Plant diseases. Detection and estimation of infestation and losses in different crops;

Assignment: Each student has to submit 25 major insect pests as rearings and 50 insect pests as preserved/mounted/carded specimens from field and horticultural crops.

THEORY LECTURE SCHEDULE

Economic importance, distribution, seasonal incidence, host range, bionomics and Integrated pest management strategies of major insect and non-insect pests of following crops:

1. Rice – borers and leaf feeders.
2. Rice – sucking pests and non-insect pests.
3. Wheat and maize.
4. Minor millets.
5. Pulses.
6. Groundnut, sesame.
7. Sunflower, safflower, castor and mustard.
8. Sugarcane and sugarbeet.
9. Cotton and jute.
10. Tobacco, arecanut and betelvine.
11. Green manures and forage crops.
12. Brinjal, bhendi, tomato.
13. Cucurbits.
14. Crucifers.
15. Moringa and amaranthus.
16. Tuber crops - Potato, sweet potato, tapioca and yam.
17. **Mid Semester Examination**
18. Pepper, cardamom, cinnamon.
19. Chillies, onion, garlic.
20. Ginger, turmeric and coriander, curry leaf, tamarind and mint.
21. Coconut and oil palm.
22. Coffee.
23. Tea and cocoa.
24. Mango, sapota and citrus.
25. Banana, grapevine, guava, cashew.
26. Jack, pomegranate, pineapple, papaya and ber.
27. Apple, plum, peach and others.
28. Rose, jasmine, chrysanthemum, crossandra, tuberose, marigold and nerium.
29. Neem, teak, sandalwood, eucalyptus and casuarina.
30. Lawn; Ornamental crops: Crotons, gladiolus, gerbera, lily andCarnation.
31. Ocimum, senna, periwinkle, glory lily, ashwagandha, aloe and noni.
32. Mushroom pests; Green house pests; Non insect pests.

33. Rodents, mites, nematodes and birds.
34. Locusts; insect vectors of plant diseases – Major groups and major diseases transmitted by them. Current trends in crop pest management.

PRACTICAL SCHEDULE

Identification of symptoms of damage and life stages of important pests of following field and horticultural crops

1. Cereals: Rice, maize.
2. Wheat and millets.
3. Pulses.
4. Oilseeds: Groundnut, sesame, sunflower, safflower, castor and mustard.
5. Sugar crops: Sugarcane and sugarbeet.
6. Fibre crops: Cotton and jute.
7. Masticatories: Tobacco, arecanut and betelvine, green manures and forage crops.
8. Pests of Vegetables: brinjal, bhendi, tomato, cucurbits, crucifers, moringa and amaranthus.
9. Tuber crops: Potato, sweet potato, tapioca and yam.
10. Spices and condiments - Pepper, cardamom, clove, nutmeg, chillies, onion, garlic, ginger, turmeric, coriander, curry leaf, tamarind and mint.
11. Plantation and beverage crops: Coconut, oil palm, rubber, coffee, tea and cocoa.
12. Tropical fruits: Mango, sapota and citrus, banana, grapevine and guava.
13. Tropical fruits: Cashew, jack, pomegranate, pineapple, papaya, ber, date palm, jamun; temperate fruits: Apple, plum, peach and others.
14. Flower crops: Rose, jasmine, chrysanthemum, crossandra, tuberose, marigold and nerium. Tree crops: Neem, teak, sandalwood, eucalyptus and casuarina.
15. Pests of Lawn; Ornamental crops: Crotons, gladiolus, gerbera, lily and carnation. Medicinal plants: Ocimum, senna, periwinkle, glory lily, ashwagandha, aloe and noni.
16. Mushroom pests; Green house pests; Non-insect pests: Rodents, mites, nematodes and birds.
17. Locusts; Insect vectors of plant diseases – Major groups.

Course Outcomes

CO1: Skillsin identifying the major pests infesting crop plants.
CO2: Proficiency in identifying symptoms of damage caused by pests on crops.
CO3: Knowledge on bionomics and bio-ecology of major pests infesting crop plants.
CO4: Expertise inintegrated management of major pests on crops.
CO5: Skills in identifying important insect vectors of plant diseases.

CO -PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3

CO 4	3	3	3	3	3
CO 5	3	3	3	3	3

Suggested Reading:

1. Awasthi, V.B. 2007. *Agricultural Insect Pests and their Control*, Scientific Publishers India, Jodhpur, 267 p.
2. Butani, D.K. and M.G. Jotwani. 2017. *Insects in Vegetables*, Daya Publishing House, New Delhi, 356 p.
3. Chavai, A.M. 2015. *Identification and Management of Horticultural Pests*, New India Publishing Agency, New Delhi. 378 p.
4. Dhaliwal G.S. and O. Koul. 2011. *Biopesticides and Pest Management*, Kalyani Publishers, India, 386 p.
5. Kannan, R., C. Kathirvelu and R. Veeravel. 2016. *Crop Pest Management*, Manibharathi Publications, Chidambaram, 456 p.
6. Marcelo, L.L. and S. Sonia. 2012. *Integrated Pest Management and Pest Control – Current and Future Tactics*, InTech Publishers, New Delhi, 682 p.
7. Regupathy, A. and R. Ayyasamy. 2015. *A Guide on Crop Pests*, Namrutha Publications, Coimbatore. 385 p.
8. Sathe, T.V. 2017. *Pests of Ornamental Plants*, Daya Publishing House, New Delhi, 199 p.
9. Srivastava, K.P. 2013. *A Text Book of Applied Entomology*, Part – II. Kalyani Publishers, India, 305 p.
10. Vasantharaj David, B. and V.V. Ramamurthy. 2016. *Elements of Economic Entomology*, Eighth Edition, Brillion Publishing, New Delhi. 625 p.

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- www.knowledgebank.irri.org/step-by-step-production/growth/pests-and-diseases/insects
- http://www.rkmp.co.in/category/eistags/eis/production-know-how/crop-protection/insects/insect-pests-of-national-importance
- http://www.ncipm.org.in/nicra/NICRAPDFs/Manuals/Manual%20for%20Rice%20Pest%20Surveillance.pdf
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_pest.html
- http://farmer.gov.in/ipmpackageofpractices.html

ENT 504 - Insect Ecology (2+0)

Course Objectives

- To impart the concepts of ecology, basic principles of distribution and abundance oforganisms and their causes.
- To study life tables, constructing life tables, organizationof communities, diversity indices.
- To train students in sampling methodology,calculation of diversity indices, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

Unit I: Introduction

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

Unit II: Insect abundance

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

Unit III: Biotic factors

Biotic factors- Food as a limiting factor for distribution and abundance, NutritionalEcology. Food chain- web and ecological succession. Interspecific interactions- Basicfactors governing the interspecific interactions- Classification of interspecificinteractions – The argument of cost-benefit ratios. Competition- Lotka-Volterramodel, Concept of niche ecological homologues, competitive exclusion. Evolution ofmimicry, colouration, concept of predator satiation; evolution of life history strategies.

Unit IV: Community Ecology

Community ecology- Concept of guild, Organisation of communities- HutchinsonRatio, May's *d/w*, Relation between the two and their association with Dyar's Lawand Przibram's law. Relative distribution of organisms, Concept of diversity- theWallacian view. Assessment of diversity. Diversity- stability debate,

Unit V: Insect Ecology and Pest Management

Insect ecology and pest management. Pest management as applied ecology. Climate change and insectpest/ natural enemy population; ecological engineering. Current trends in insect ecology.

Practical

Types of distributions of organisms;Methods of sampling insects, estimation of densities of insects and understandingthe distribution parameters- Measures of central tendencies, Poisson Distribution,Negative Binomial Distribution;Determination of optimal sample size. Learning to fit basic population growthmodels and testing the goodness of fit;Fitting Holling's Disc equation;Assessment of prey-predator densities from natural systems and understandingthe correlation between the two;Assessing and describing niche of some insects of a single guild;Calculation of niche breadth, activity breadth and diagrammatic representationof niches of organisms;Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index andunderstanding their associations and parameters that affect their values;Problem solving in ecology. Field visits to understand different ecosystems and tostudy insect occurrence in these systems.

Theory Schedule

1. History and definition of insect ecology. Basic Concepts.
2. Organisation of the Biological world. Plato's Natural Balance *vs* Ecological Dynamics as the modern view.
3. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two.
4. Basic principles of abiotic factors and their generalised action on insects.
5. Implications for abundance and distribution of organisms including insects.
6. Law of the Minimum, Law of Tolerance, and biocoenosis.
7. Systems approach to ecology.
8. Basic concepts of abundance- Model *vs* Real world.
9. Population growth basic models – Exponential *vs* Logistic models. Discrete *vs* Continuous growth models.
10. Concepts of Carrying capacity, Environmental Resistance and Optimal yield.
11. Vital Statistics- Life Tables and their application to insect biology.Survivorship curves
12. Case studies of insect life tables.
13. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration.
14. Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) – aestivation, hibernation.
15. Biotic factors- Food as a limiting factor for distribution and abundance.
16. Nutritional Ecology. Food chain- web and ecological succession.
17. **Mid Semester Examination**
18. Interspecific interactions- Basic factors governing the interspecific interactions.
19. Classification of interspecific interactions.
20. The argument of cost-benefit ratios.
21. Competition- Lotka-Volterra model.
22. Concept of niche ecological homologues, competitive exclusion.
23. Evolution of mimicry, colouration.
24. Concept of predator satiation.
25. Evolution of life history strategies.
26. Community ecology- Concept of guild.
27. Organisation of communities- Hutchinson Ratio, May's *d/w*, Relation between the two and their association with Dyar's Law and Przibram's law.
28. Relative distribution of organisms, Concept of diversity- the Wallacian view.
29. Assessment of diversity. Diversity- stability debate.
30. Insect ecology and pest management.
31. Pest management as applied ecology.
32. Climate change and insect pest/ natural enemy population.
33. Ecological engineering.
34. Current trends in insect ecology.

Course outcome

CO 1: Well versed knowledge on basic concepts of ecology.

CO 2: Knowledge on different insect-ecosystem interactions.
CO 3: Expertise in quantification of insect diversity and abundance.
CO 4: Proficiencyin sampling methodology,calculation of diversity indices.
CO 5: Familiarity with the principles of ecological engineering.

CO -PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	2	1	2
CO 2	3	3	2	1	2
CO 3	3	3	2	2	2
CO 4	3	3	1	2	2
CO 5	3	3	1	1	2

Suggested Reading

1. Begon M, Townsend CR and Harper JL. 2006. *Ecology: From Individuals to Ecosystems*. 4th Ed.Blackwell Publishing, USA/ UK/ Australia.
2. Chapman JL and Reiss MJ. 2006. *Ecology: Principles and Applications*. 2nd Ed. CambridgeUniv. Press, Cambridge.
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E-resources

- https://en.wikipedia.org/wiki/Insect_ecology
- http://file.zums.ac.ir/ebook/760-Insect%20Ecology,%20Third%20Edition%20-%20An%20Ecosystem%20Approach=Timothy%20D.%20Schowalter=0123813514=Aca dem.pdf
- https://www.zoo.cam.ac.uk/research/groups/insect-ecology
- https://insectecology.une.edu.au/
- http://biodiversitylab.ncbs.res.in/media/KunteEtal_IndianInsects_2019_Ch16.pdf

ENT 505 - Biological Control of Insect Pests and Weeds (1+1)

Course objectives

- To study the basics and role of bio control agents in insect pest management.
- To study the mass production techniques of important biological control agents
- To study the field evaluation techniques of important biological control agents.

Theory

Unit I: Basics of biological control

Biological control - definition, history, scope, principles, successful case histories of biocontrol agents and concepts. Natural, applied and classical biological control. Scope of biological insect pest suppression –use of living organisms and their products, parasitoids, predators, entomopathogens, entomophilic nematodes, predatory mites, spiders, botanicals and semiochemicals.

Unit II: Insect parasitoids and predators

Insect Parasitoids – types, desirable attributes, important groups, biology, adaptation, host selection behavior, mass production and field release. Insect predators - types, desirable attributes, important groups, biology, adaptation, host seeking behavior, mass production techniques, formulations, economics, fieldrelease/ application and evaluation. Tritrophic interaction of parasitoids and predators.

Unit III: Entomopathogens and entomophilic nematodes

Entomopathogens – important groups – Bacteria, viruses, fungi, protozoans and rickettsiae - host range, symptoms of infections and desirable attributes. Epizootiology,
symptomatology and etiology of insect diseases. Defense mechanisms in insects against pathogens.Nematodes – important groups, host range, symptoms of attack, mass production techniques, formulations, economics, fieldrelease/ application and evaluation.

Unit IV: Non insect predators and weed killers

Predatory mites – important species, host range, biology and host seeking behavior. Spiders – important species, host range, biology and host seeking behavior. Predatory birds of agricultural importance. Weed killers-desirable attributes of weed killers – major weeds and their biocontrol agents. mass production of predatory mites and weed killers - techniques, formulations, economics, fieldrelease/ application and evaluation

Unit V: Implications of bio-control

Factors affecting efficacy of biocontrol agents conservation and augmentation, integration with IPM components, role of weeds and mixed/trap cropping and dirty field technique in enhancing natural enemy activity, Successful biological control projects, analysis, trends and future possibilities of biological control, importations of natural enemies – quarantine regulations in utilization of exotic biocontrol agents, role of biotechnology and semiochemicals in biological control. **Current trends in Biological Insect pest suppression.**

Practical

Field survey for collection of parasitoids using various methods, host rearing, net sweep and traps in agricultural and horticultural ecosystems. Diagnosis and sketching of parasitoids, predators and entomopathogens. Establishing tritrophic relationship of parasitoids and predators. Identification of predatory mites and spiders. Mass production techniques of parasitoids – *Trichogramma, Goniozus and Brachymeria*; Predators- *Chrysopa* and coccinellids. Pathogenicity and mass production of entomopathogens – NPV, *Metarrhizium*

and *Bt*. Mass production of entomophilic nematodes. Field release and evaluation of parasitoids and predators. Visits to bio-control laboratories, Quality control and registration standards for biocontrol agents.

Assignment: Each student has to submit 50 numbers of bio control agents comprising parasitoids, predators and non-insect predators (at least 10 should be from host rearing).

THEORY LECTURE SCHEDULE

1. Biological insect pest suppression – definition and scope - use of living organisms and their products.History and development of biological control in India and abroad.Principles and successful examples of biocontrol.Natural, applied and classical biological control – definition and difference.
2. Classification of bio control agents – parasitoids, predators, entomopathogens, entomophilic nematodes, predatory mites, spiders, botanicals, semiochemicals and weed killers.
3. Insect parasitoids – types, desirable attributes and important groups.
4. Biology of important parasitoids.Host selection behaviour of parasitoids.Mass production, economics and field release of parasitoids.
5. Insect predators – types, desirable attributes and important groups including vertebrate predators. Biology, adaptation and host seeking behaviour of predators.Mass production, economics and field release of predators.
6. Entomopathogens – Bacteria, Viruses, Fungi, Protozoans and Rickettsiae – important groups, examples, host range, symptoms of infections and desirable attributes. Mass production, formulation, economics and field application of entomopathogens.
7. Tritrophic interaction – host plant - host insect - parasitoid/predator.
8. Entomophilic nematodes – important groups, host range and symptoms of attack. Mass production, formulation and field application of entomophilic nematodes.
9. **Mid semester examination**
10. Predatory mites, Predatory Spiders – important species, host range, biology and host seeking behaviour.
11. Weed killers – desirable attributes, important species, host range and biology.
12. Factors affecting efficacy of bio control agents.
13. Conservation and Augmentation of bio control agents.
14. Integration of IPM components, role of weeds/refugia mixed / trap crop and dirty field technique in enhancing natural enemy activity.
15. Future possibilities of biological control, importation of natural enemies -Quarantine regulation in utilization of exotic bio-control agents.
16. Role of biotechnology and semiochemicalsin biological control.
17. Current trends in biological control.

PRACTICAL SCHEDULE

1. Identification and sketching of important Chalcidoidea parasitoid families of agricultural importance.
2. Identification and sketching of other parasitoid families of agricultural importance.
3. Identification and sketching of important insect predators of agricultural importance.
4. Identification and sketching of other invertebrate and vertebrate insect predators.
5. Identification and sketching of important entomopathogens and entomophilic nematodes of agricultural importance.
6. Identification and sketching of important predatory mites, spiders and weed killers of agricultural importance.
7. Mass production techniques of *Trichogramma* and *Brachymeria.*
8. Mass production techniques of *Chrysopa*andCoccinellids.
9. Practicing tritrophic interaction.
10. Mass production techniques of NPV.
11. Pathogenicity of NPV to *Helicoverpa /Spodoptera* and *Metarrhizium*to Rhinoceros beetle grub.
12. Mass production techniques of *Metarrhizium* and *Beauveria.*
13. Mass production techniques of *Bacillus thuringiensis* andSpore staining.
14. Pathogenicity of*Bt*to*Helicoverpa / Plutella.*
15. Experimentation of semiochemicals in host selection.
16. Experiment on compatibility of biocontrol agents with botanicals and agro chemicals.
17. Visit to NBAIR / production unit of biocontrol agents.

Course Outcomes

CO1: Skills in identifyingimportant biological control agents.
CO2: Knowledge about thebiology and adaptations of insect predators and parasitoids.
CO3: Skills in mass production and field release of major biocontrol agents.
CO4: Knowledgeabout role of non-insect predators and weed killers.
CO5: Knowledge on implications of biocontrol programmes.

CO -PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	2	2	1
CO 2	3	3	1	3	1
CO 3	3	3	2	3	1
CO 4	3	3	1	2	1
CO 5	3	3	1	3	1

Suggesting Reading:

1. Clausen, C.P. 1940. Entomophagous Insects. McGraw Hill Book Company, USA, 687 p.
2. Consoli, F., L. Parra, R.P. José and R. Zucchi. 2010. *Egg Parasitoids in Agroecosystems with Emphasis on Trichogramma*, Springer, Netherlands, 482 p.
3. Coppel, H.C. and J.W. Mertins. 2011. *Biological Insect Pest Suppression*, Springer-Verlag, New York, 314 p.

4. De Bach, P. 1970. *Biological Control of Insect Pests and Weeds*, Chapman and Hall Ltd., London, 844 p.
5. De Bach, P. 1979. *Biological Control by Natural Enemies,* Cambridge University Press, London, 323 p.
6. Singh, S.P. 2004. *Some success stories in Classical Biological control of Agricultural pests in India*, Asia-Pacific Association of Agricultural Research Institutions, FAO Regional office for Asia and the pacific, Bangkok, Thailand, 73 p.
7. Sithanantham, S., C.R. Ballal, S.K. Jalali and N. Bakthavatsalam. 2013. Biological Control of Insect Pests using Egg Parasitoids, Springer, India, 424 p.
8. Tandon, P.L., C.R. Ballal, S.K. Jalali and R.J. Rabindra. 2003. *Biological Control of Lepidopteran Pests*. Society for Biocontrol Advancement, NBAIR, Bangalore, India, 354 p.
9. Vega, F.E. and H.K. Haya. 2012. *Insect Pathology*, Academic Press, New York, 502 p.
10. Waterhouse, D.F. and D.P.A. Sands. 2001. *Classical Biological Control of Arthropods in Australia*. CSIRO Entomology, Canberra, Australia, 559 p.

E-resources:

1. http://www.nhm.ac.uk/chalcidoids
2. http://osuc.biosci.ohio-state.edu/hymDB/eol_scelionidae.home
3. www.nbair.res.in/IndianMymaridae/index.php
4. www.nbair.res.in/Chalcididae/index.php
5. www.nbair.res.in/Aphelinidae/index.php

ENT 507 – HostPlant Resistance(1+1)

Course Objectives

- To orient the students towards the process of host selection process by insects
- To impart knowledge on the various mechanisms and factors of resistance in crop plants against insect pests.
- To train students in various breeding and molecular tools employed for exploiting resistance in crop germplasm

Theory

Unit I: Basics of host plant resistance

Host plant resistance – History, importance, definitions – advantages and disadvantages – Insect-host plant relationship – Host selection process by insects- role of allelochemicals in host selection.

Unit II: Mechanisms and factors of resistance

Classification of resistance – ecological/pseudo resistance – host evasion, escape and induced resistance. Genetic resistance. Mechanisms of resistance – antixenosis, antibiosis and tolerance. Biophysical factors – Trichomes – Glandular, non-glandular and other morphological characters. Biochemical factors – volatiles and secondary plant substances, chemical ecology, tritrophic relations.

Unit III: Genetic and induced resistance

Genetics of crop resistance to insects, factors influencing resistance, breeding for resistance – methods – problems and prospects. Stability of resistance – biotype development and measures to combat biotypes. Induced resistance – Elicitors – Forms of IR – ISR, SAR – Mechanisms; Plant defense – Phytohormones – JA, SA Pathways- Role of endophytes.

Unit IV: Insect resistance in major crops

Successful examples of resistant crop varieties in India and world – resistance to key pests in rice, maize, sorghum, sugarcane, cotton, pulses, oilseeds, vegetable and fruit crops – achievements and future thrusts – Methods of evaluation of resistance.

Unit V: Biotechnological approaches in plant resistance

Biotechnological tools in host plant resistance –utilization of wild species – identification of genes responsible for resistance. Marker aided selection – Incorporation of genes for resistance into crop varieties – transgenic crops, their status, scope and limitations. Molecular techniques – cloning. **Current trends in plant resistance to pests.**

Practical

Mass culturing of homopteran and lepidopteran insects for screening. Screening methodologies and evaluation techniques for resistance to key pests in rice, sorghum, pulses, cotton, sugarcane and vegetables. Antixenosis and antibiosis mechanisms of resistance to major pests in rice, cotton, and vegetables. Estimation of biophysical and biochemical factors of resistance. Important nutritional factors imparting resistance – carbohydrates, phenols etc.

THEORY LECTURE SCHEDULE

1. History, importance and definition, status, scope, and limitations of plant resistance to pests.
2. Insect – host plant relationship – host selection by phytophagous insects.
3. Classification of host plant resistance.
4. Mechanisms of resistance – antixenosis.
5. Mechanisms of resistance – antibiosis and tolerance.
6. Biophysical factors of resistance – Trichomes and other morphological characters.
7. Bio chemical factors of resistance- volatile and secondary plant substances; Chemical ecology – tritrophic relations.
8. Genetic basis of resistance, abiotic and biotic factors influencing resistance in plants.
9. **Mid semester examination**
10. Breeding for resistance – methods, problems and prospects.
11. Stability of resistance – insect biotypes – development and their management.
12. Induced resistance – Elicitors – Forms of IR – ISR, SAR – Mechanisms; JA, SA Pathways- Role of endophytes, Exogenous application of elicitors.

13. Successful examples, future thrusts of insect resistance in crop varieties in India and world – cereals, millets, insect resistance in sugarcane, cotton and pulses.
14. Successful examples, future thrusts of insect resistance in crop varieties in India and world – oilseeds, fruits and vegetables.
15. Biotechnological tools in host plant resistance.
16. Utilization of wild species – identification and incorporation of genes of interest and marker aided selection.
17. Genetic engineering and plant resistance – status, scope and limitations of transgenic crop varieties. Current trends in plant resistance to pests research

PRACTICAL SCHEDULE

1. Mass culturing of rice brown planthopper / aphids / whiteflies.
2. Mass culturing of diamond back moth / *Spodoptera* / *Helicoverpa* / rice leaf folder.
3. Green house methodology for screening of rice varieties against brown planthopper. standard seed box test and modified seed box for grading and grouping.
4. Methodology and evaluation of resistance in rice to stem borer and leaf folder.
5. Methodology and evaluation of resistance in sorghum to key insect pests.
6. Methodology and evaluation of resistance in cotton to key insect pests.
7. Methodology and evaluation of resistance in sugarcane to key insect pests.
8. Methodology and evaluation of resistance in vegetables to key insect pests.
9. No- choice test for studying preference / non- preference of rice / cotton / tomato / bhendi varieties against major insect pests.
10. Locating feeding punctures of green leaf hopper on resistant and susceptible rice varieties using safranine dye technique.
11. Growth and development of brown plant hopper / leaf folder on resistant and susceptible rice varieties – no choice test for studying antibiosis.
12. Studying feeding preference of brown plant hopper in resistant and susceptible rice varieties.
13. Estimation of biophysical factors of resistance in the foliage of rice / cotton / bhendi / tomato varieties.
14. Estimation of biophysical factors of resistance in the fruits of tomato / bhendi, cotton bolls and bracts and sesame capsules.
15. Estimation of total and O.D. phenols in tomato / cotton varieties and silica in rice varieties.
16. Estimation of reducing and non – reducing sugars in tomato / bhendi varieties.
17. Estimation of secondary substances in crop varieties – gossypol in cotton, tomatine/lycopene in tomato and solanin in brinjal.

Course Outcomes

CO1: Understand the host selection behavior of insects.
CO2: Capable of understanding the mechanisms of resistance.

CO3: Expertise in biophysical and biochemical bases of resistance.
CO4: Proficiency in biotechnological approaches in host plant resistance.
CO5: Capable of utilizing the resistant varieties in IPM

CO–PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	2	2	2
CO 2	3	3	3	3	2
CO 3	3	3	3	3	2
CO 4	3	3	2	2	1
CO 5	3	3	2	2	1

Suggested Reading:

1. Arora, R. and S. Sandhu. 2017. *Breeding Insect Resistant Crops for Sustainable Agriculture*, Springer, Berlin, 421 p.
2. Dhaliwal, G.S. and R. Singh. (Eds.). 2004. *Host Plant Resistance to Insects – Concepts and Applications*, Panima Publishing Corporation, New Delhi, 578 p.
3. Dhaliwal, G.S. and Dilawari,V.K. 1993. *Advances in Host plant Resistance to Insects*, Kalyani Publishers, New Delhi, 443 p.
4. Painter, R.H. 1951. *Insect Resistance in Crop Plants*, The Mac Millan Co., New York. 520 p.
5. Panda, N. and G.S. Khush. 1995. *Host Plant Resistance to Insect Pests*, CAB International, Walling Ford, 431 p.
6. Sadasivam, S. and B. Thayumanavan. 2003. *Molecular Host Plant Resistance to Pests*, Marcel Dekker, New York, 479 p.
7. Sharma, H.C. 2014. *Biotechnological Approaches for Pest Management and Ecological Sustainability*, CRC Press, USA, 526 p.
8. Smith, C.M. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches*, Springer, Berlin, 423 p.
9. Smith, C.M., Z.R. Khan and M.D. Pathak. 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*, CRC Press Inc., USA, 320 p.
10. Maxwell FG and Jennings PR. (Eds). 1980. *Breeding Plants Resistant to Insects.* John Wiley and Sons, New York. 683 p.

E -References

1. http://www.icrisat.org/
2. http://iapreviews.ars.usda.gov/research/docs.htm?docid=22702
3. http://www.crri.nic.in/
4. http://hau.ernet.in/
5. https://entomology.k-state.edu/department-info/links/painter-collection.html

ENT 508 –Conceptsof Integrated Pest Management (2+0)

Course Objectives

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

Theory

Unit I: History and Concepts of IPM

History, origin, definition of IPM. National and international organizations. Pest - definition, categories, biotypes, losses and causes for outbreaks - Ecological principles in pest management - economic threshold concepts (EIL and ETL)

Unit II: Tools of IPM

tools of pest management and their integration; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys – Agro Ecosystem Survey Analysis.

Unit III: Components of IPM

Legislative, cultural, physical, mechanical, host plant resistance, biological, botanical, chemical and other biorational methods – sterile male technique, chemosterilants, insect growth regulators, moult inhibitors, juvenile hormone mimics, antifeedants and repellants. Biotechnology in pest management – transgenic crops.

Unit IV: Implications of IPM

Political, social and legal implications of IPM, pest and pesticide risk analysis, benefit cost ratio and partial budgeting. FFS and Plant clinic centres, IPM village - case studies.

Unit V: IPM for crops

Successful IPM programmes in various crops viz.,rice, cotton, sugarcane, vegetables,coconut, plantations etc. ITK-s in IPM, area-wide IPM, IPM for organic farming; components of ecological engineering with successful examples. Current trends in Integrated Pest Management.

Lecture Schedule

1. History, origin, definition of IPM. National and international organizations.
2. Pest - definition, categories, biotypes, losses.
3. Causes for Pest outbreaks.
4. Ecological principles in pest management - economic threshold concepts (EIL and ETL).
5. Tools of pest management and their integration.
6. Pest survey and surveillance.
7. Forecasting, types of surveys including remote sensing methods.
8. Factors affecting surveys.
9. Agro Ecosystem Survey Analysis.
10. Legislative methods.
11. Cultural methods of pest management.
12. Physical methods of pest management.
13. Mechanical methods of pest management.
14. Host plant resistance as pest management tool.

15. Biological methods of pest management.
16. Botanicals as pest management tools.
17. **Mid Semester Examination**
18. Chemical methods of pest management.
19. Other biorational methods – sterile male technique, chemosterilants, insect growth regulators, moult inhibitors, juvenile hormone mimics, antifeedants and repellants.
20. Biotechnology in pest management – transgenic crops.
21. Political, social and legal implications of IPM.
22. Pest and pesticide risk analysis.
23. Benefit cost ratio and partial budgeting.
24. FFS and Plant clinic centres, IPM village - case studies.
25. IPM in rice.
26. IPM in cotton.
27. IPM in Sugarcane.
28. IPM in Vegetables.
29. IPM in Coconut.
30. IPM in plantation crops.
31. ITK-s in IPM.
32. Area-wide IPM.
33. IPM for organic farming.
34. Components of ecological engineering with successful examples.Current trends in Integrated Pest Management.

Course outcome

CO1: Significant knowledge onvarious concepts of IPM.
CO2: Expertise in estimation of losses due to insect pests.
CO3: Knowledge on computation of ETL, EIL.
CO4: Proficiency in the practice of establishing plant clinic centres, FFS.
CO5: Capable of takingintegrated pest management decisions for various crops.

CO–PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	1	1	1
CO 2	3	3	3	2	1
CO 3	3	3	3	3	3
CO 4	3	3	3	3	2
CO 5	3	3	3	3	1

Suggested Reading

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

2. Horowitz AR and Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.
3. Ignacimuthu SS and Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.
4. Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management.* Prentice Hall, New Delhi.
5. Pedigo RL. 2002. *Entomology and Pest Management.* 4th Ed. Prentice Hall, New Delhi.
6. Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.*Marcel Dekker, New York.

E-resources

- https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles
- https://content.ces.ncsu.edu/extension-gardener-handbook/8-integrated-pest-management-ipm
- http://npic.orst.edu/pest/ipm.html
- http://ppqs.gov.in/divisions/integrated-pest-management/components-ipm
- https://croplife.org/crop-protection/stewardship/integrated-pest-management/

ENT 511 - Post-Harvest Entomology(1+1)

Course Objectives

- To focus on requirement and importance of grain and grain storage
- To explain the significant of stored grain pests
- To acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory

Unit I: Significance of post-harvest pests

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: Post-harvest pests

Important insects and mites associated with stored grain and field conditions including agricultural products; 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.

Unit III: Ecology of post-harvest pests and storage structures

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: Non-Insect pests on post-harvest products

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.

Unit V: Management of post-harvest pests

Control of infestation by insect pests, mites. 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. Current trends in post-harvest pest management.

Practical

Collection, identification and familiarization with the stored grains/ seed insectpests 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 storedfood grains;Determination of moisture content in stored food grains;Familiarization of storage structures, demonstration of preventive and curativemeasures including fumigation techniques;Treatment of packing materials and their effect on seed quality;Field visits to save grain campaign, central warehouse and FCI warehouses andinstitutions engaged in research or practice of grain storage (only where logistically feasible).

Lecture Schedule

1. Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests.
2. 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.
3. Important insects and mites associated with stored grain and field conditions including agricultural products; their systematic position, identification, distribution, host range, biology, nature and extent of damage.
4. Role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality.
5. 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.
6. Stored grain deterioration process, physical and biochemical changes and consequences.
7. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

8. Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows.
9. **Mid semester Examination**
10. Role of bird pests and their management.
11. Control of infestation by insect pests, mites. Preventive measures- Hygiene/ sanitation, disinfestations of stores/ receptacles,
12. Legal measures in stored grain pest management.
13. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering.
14. Chemical control - prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants.
15. Insecticide resistance in stored product pests and its management.
16. Recent advances (MAS, PPP, HS) in storage pest management.
17. Integrated approaches to stored grain pest management. Current concepts in post-harvest entomology.

Practical Schedule

1. Collection, identification of external feeders infesting stored grains/ seed and nature of damage caused by them.
2. Collection, identification ofinternal feeders infesting stored grains/ seed and nature of damage caused by them.
3. Collection, identification ofother insects infesting stored grains/ seed and nature of damage caused by them.
4. Mass culturing procedure for major insect pests for post-harvest entomology research.
5. Detection of hidden insect infestation in stored food grains.
6. Estimation of insect population / progeny infesting stored grains using traps.
7. Estimation of insect population / progeny infesting stored grains using other methods.
8. Estimation of uric acid content in infested produce.
9. Estimation of losses in storedfood grains.
10. Determination of moisture content in stored food grains.
11. Familiarization of storage structures.
12. Demonstration of preventive measures in storage godowns.
13. Demonstration of curativemeasures - Non-chemical techniques.
14. Demonstration of curative measures - Chemical techniques including fumigation.
15. Treatment of packing materials and their effect on seed quality.
16. Field visits to save grain campaign, central warehouse and FCI warehouses.
17. Visits toinstitutions engaged in research or practice of grain storage (only where logistically feasible).

Course outcome

CO1: Knowledge on pestiferous insects, mites, rats andbirds affecting stored produce, their nature of damage and life history traits

CO2: Proficiency in the detection of insect infestation and estimation of insect population
CO3: Knowledge on different storage structures.
CO4: Learning preventive and curative measures to manage infestation in storagehouses.
CO5: Understanding the functioning of Central / FCI warehouses with relevance to pest management

CO–PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	1	1	1
CO 2	3	3	2	1	1
CO 3	3	3	3	1	2
CO 4	3	3	2	3	2
CO 5	3	3	2	1	3

Suggested Reading

1. 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.
2. Jayas DV, White NDG and Muir WE. 1995. *Stored Grain Ecosystem.* Marcel Dekker, New York.
3. Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publishers, New Delhi.
4. Khare BP. 1994. *Stored Grain Pests and Their Management.* Kalyani Publishers, New Delhi.
5. Subramanyam B and Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products.* Marcel Dekker, New York.

E-resources

- https://igmri.dfpd.gov.in/
- https://igmri.dfpd.gov.in/igmri/insect-culture-lab
- https://extension.entm.purdue.edu/publications/pubs/stored.html
- https://entomology.ca.uky.edu/ef145
- https://storedproductinsects.com/columns/extension-websites/

ENT 518 – LacCulture (2+0)

Course Objectives

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

Theory

Unit I: History of lac culture and strains of lac insects

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: Cultivation of host plants of lac insects

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: Morphology and Biology of lac insects

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: Lac farming

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: Processing and marketing of lac

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. Current trends in lac production.

Theory Schedule

1. History of lac production and its importance.
2. Potential of lac production in India.
3. Organizations involved in lac production activities.
4. Strains of lac insects and lac crops – distribution, area and production of different strains of lac.
5. Lac host plant species, ecological requirements, their cultivation.
6. Seasons of host plants, harvest time of host plants.
7. Rearing seasons; grouping of host trees.
8. Pruning methods and timing of pruning.
9. Pests and diseases on Lac host plants and their management.
10. Basic morphology of lac insect.
11. Basic taxonomy of lac insect.
12. Strains of lac insect and their characteristics.
13. Composition of lac.
14. Biology of lac insect.

15. Introduction to Lac farming lac insect-host plant interaction.
16. Selection of brood lac, local practices, improved alternatives.
17. **Mid Semester Examination**
18. Coupe system.
19. Propagation of lac insects: natural self-inoculation, artificial inoculation.
20. Inoculation process and duration; removal of phunki.
21. Harvesting of lac, immature harvesting, mature harvesting and time of harvesting.
22. Predators and parasitoids of lac insect, hyperparasites.
23. Diseases and their management.
24. Lac production stages.
25. Factors affecting yield and quality of shellac.
26. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method.
27. Technology of brood preserving.
28. Host-specific technologies – cultivation on specific host plants.
29. Integration of lac cultivation with agro-forestry and horticulture.
30. Socio-economic potential of lac cultivation.
31. Lac processing and value addition.
32. Marketing of lac and its products.
33. Export-import of lac/ lac products.
34. Entrepreneurship development.Current trends in lac production.

Course outcome

CO1: Knowledge of importance of lac cultivation in India.
CO2: Expertise in identifying lac host trees and theirmaintenance for lac production.
CO3: Acquaintance with the suitable techniques for lac production.
CO4: Expertise in identifying diseases and natural enemies of the lac insect.
CO5: Information on processing and marketing of lac.

CO–PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	1	1	1
CO 2	3	3	1	1	1
CO 3	3	3	3	1	1
CO 4	3	3	2	1	1
CO 5	3	3	2	2	1

Suggested Reading

- Arvind Kumar and Rameshwar Das. 2013. *Prospects of Scientific Lac Cultivation in India*, Institute of Forest Productivity, Ranchi.
- Chattopadhyay, S. 2011. *Introduction to Lac and Lac culture*, Birsa Agricultural University.
- David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

- Sharma KK and Ramani S. 2010. *Recent advances in lac culture*. ICAR-IINRG, Ranchi.
- Ghorai, N. 2020. *Lac-culture in India.* Om Publications, New Delhi, 174p.

E-resources

- https://iinrg.icar.gov.in
- http://nsdl.niscair.res.in/bitstream/123456789/219/1/LAC%20CULTURE.pdf
- https://krishijagran.com/agripedia/what-are-the-stages-involved-in-lac-cultivation-know-precautions-profitable-tips-for-harvesting/
- https://agriallis.com/wp-content/uploads/2021/04/INDIAN-LAC-CULTURE-%E2%80%93-AN-OVERVIEW.pdf
- https://krishi.icar.gov.in/jspui/bitstream/123456789/41189/2/MANAGEMENT%20OF%20HOSTS%20FOR%20LAC%20CULTIVATION%20IFP.pdf

ENT 519 - Molecular Approaches In Entomology (1+1)

Course Objectives

- To acquaint students the latest techniques used in molecular biology
- To train students on the identification of genes of interest

Theory

Unit I: Introduction

Introduction to molecular biology, history, techniques used in molecular biology.

Unit II: Molecular Techniques

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

Unit III: Exploration of genes of interest

Genes of interest in entomological research- marker genes for sex identification, peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Plantderived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-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: Genetic Engineering

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: Implication of transgenics

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 insectpests, DNA-based diagnostics. Nano technology and its application.

Practical

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

Theory Schedule

1. Introduction to molecular biology.
2. History, techniques used in molecular biology.
3. DNA recombinant technology.
4. Identification of genes/ nucleotide sequences for traits of interestin plants and microbes.
5. Genes of interest in entomological research- marker genes for sex identification, peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Plant derived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terpenes and terpenoids.
6. 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.
7. Genetically engineered microbes and parasitoids in biological control.
8. Genetic engineering of baculoviruses for greater efficacy against insect pests.
9. **Mid Semester Examination**
10. Genetic engineering of fungal biocontrol agents for greater efficacy against insect pests.
11. Effects of transgenic plants on pest biology and development.
12. Resistance management strategies in transgenic crops.
13. Molecular mechanism of insecticide resistance.
14. Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique, release of insects carrying a dominant lethal gene.
15. Methods and application of insect transgenesis,transgenics in silkworm and honeybees.
16. Molecular tools for taxonomy and phylogeny of insect pests.
17. DNA-based diagnostics. Nano technology and its application.

Practical Schedule

1. Preparation of buffers
2. Isolation of Insect DNA
3. Isolation of insect RNA
4. Restriction endonuclease analysis of DNA/RNA
5. Agarose gel electrophoresis of DNA
6. Agarose gel analysis
7. Quantification of DNA using spectrophotometry
8. Purity check of DNA
9. PCR amplification of DNA
10. Cloning PCR products in commercial vectors
11. Confirmation of inserted DNA
12. Miniprep of recombinant plasmid DNA
13. Blast analysis
14. Isolation of host plant proteins
15. SDS-PAGE of plant proteins
16. Analysis of banding pattern using gel documentation
17. Visit to NBAIR / TNAU Molecular Biology unit

Course outcome

CO1: The students are expected to be well versed with the basic techniques inmolecular biology.

CO2: The students are expected to get trained on identification of genes of interest

CO3: To keep the students abreast on the latest genetic engineering tools

CO4: To enlighten the students on the implications of transgenes

CO5: To develop skills in nano technology

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	3	3	2
CO 2	3	3	3	3	2
CO 3	3	3	3	3	2
CO 4	3	3	3	3	2
CO 5	3	3	3	3	2

Suggested Reading

1. Bhattacharya TK, Kumar P and Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publication, New Delhi.
2. Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. *Molecular Insect Science.* Plenum Press, New York.
3. Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.
4. Oakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.
5. Rechcigl JE and Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests.* Lewis Publ., North Carolina.

6. Roy U and Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publishers, New Delhi.
7. Singh BD. 2008. *Biotechnology (Expanding Horizons)*. Kalyani Publishers, New Delhi.
8. Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publishers, New Delhi.

ENT 520 –PlantQuarantine, Bio-safety and Bio-security (2+0)

Course Objectives

- 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.
- To facilitate students to have agood understanding of the aspects of biosafety and biosecurity.

Theory

Unit I: Introduction

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. Invasive Alien Insects in India.

Unit II: Quarantine Legislations

Plant protection organizations 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: Quarantine procedures

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: Biosecurity

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.

Unit V: Biosafety

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops. Current concepts in plant quarantine, biosecurity and biosafety.

Lecture Schedule

1. Definition of pest, pesticides and transgenics as per Govt. notification; relative importance.
2. Quarantine – domestic and international perspectives.
3. Quarantine restrictions in the movement of agricultural produce, seeds and planting material.
4. Case histories of exotic pests and their status.
5. Case histories of exotic diseases and their status.
6. Invasive Alien Insectsin India.
7. Plant protection organizations in India.
8. Acts related to registration of pesticides and transgenics.
9. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procedures.
10. History of quarantine legislations, PQ Order 2003.
11. Environmental Acts.
12. Industrial registration.
13. APEDA.
14. Import and Export of bio-control agents.
15. Identification of pest/ disease free areas.
16. Contamination of food with toxigens, microorganisms and their elimination.
17. **Mid Semester Examination**
18. Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations.
19. VHT and other safer techniques of disinfestation/ salvaging of infected material.
20. WTO regulations on biosecurity; non-tariff barriers.
21. Pest risk analysis.
22. Good laboratory practices for pesticide laboratories.
23. Good practices for pesticide industry.
24. Sanitary and phytosanitary measures.
25. Global Positioning System (GPS) for plant biosecurity.
26. Geographic Information System (GIS) for plant biosecurity.
27. Pest/ disease and epidemic management
28. Strategies for combating risks and costs associated with agroterrorism event.
29. Mitigation planning for agroterrorism event.
30. Integrated approach for biosecurity.
31. Biosafety, policies and regulatory mechanism.
32. Cartagena Protocol on Biosafety and its implications.

33. Issues related to release of genetically modified crops.
34. Current concepts in Quarantine, biosecurity and biosafety.

Course outcome

CO 1: Knowledge on rules and regulations of Plant Quarantine

CO 2: UnderstandingWTO regulations and GAP

CO 3: Familiaritywith Sanitary and Phytosanitary measures

CO 4: Facts on genetically modified crops

CO 5: Knowledge on import and export of bio-control agents

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	1	-
CO 2	3	3	1	1	-
CO 3	3	3	1	1	-
CO 4	3	3	1	1	-
CO 5	3	3	1	1	-

Suggested Reading

1. Gordh, G. and McKirdy, S. 2014. *The Handbook of Plant Biosecurity: Principles and Practices for the Identification, Containment and Control Organisms that threaten Agriculture and the Environment Globally*. Springer, 738 p.
2. Muthaiyan, M.C. 2009. *Principles and Practice of Plant Quarantine*. Allied Publishers, New Delhi.
3. Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.
4. Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental), CRC Press.
5. Shukla A and Veda OP. 2007. *Introduction to Plant Quarantine*. SamayPrakashan, New Delhi.

E-resources

- https://plantquarantineindia.nic.in/PQISMain/Default.aspx
- https://agricoop.nic.in/sites/default/files/Guidelines%20for%20the%20Strengthening%20and%20Modernization%20of%20Plant%20Quarantine%20Facilities%20in%20India.pdf
- https://www.bioversityinternational.org/fileadmin/bioversity/publications/Web_version/174/ch09.htm
- https://agriculture.vic.gov.au/biosecurity/moving-plants-and-plant-products/plant-quarantine-manual
- https://ccsuniversity.ac.in/bridge-library/pdf/Department-of-Plant-Protection-Plant-Quarantine-IV-semester.pdf

ENT 521 Edibleand Therapeutic Insects(1+1)

Course Objectives

- To create awareness and acquaint students about the contribution that insects make to ecosystems, diets, food security and livelihoods in developed and developing countries
- To highlight the scope of use of insects as food, feed, fertilizers besides their value as therapeutics.

Theory

Unit I: History and importance

Edible and therapeutic insects: the concept, definition, and importance.History and origin of insects as food, feed and medication; important insect species and insect products consumed.

Unit II: Nutritional status of edible insects

Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing.Nutritional composition and role of insects in food security.

Unit III: Edible insect farming

Insect farming: the concept, definitions, and rearing techniques.

Unit IV: Processing of edible insects

Processing edible insects for food and feed.Food safety and preservation, edible insects for livelihood security.

Unit V: Insects of therapeutic value

Insects used in Traditional Medicine, Insects of therapeutic value in various parts of the world, regulatory issues in using insects as therapeutics.

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-nutritionalproperties and microbial aspects of preservation.

Lecture Schedule

1. Concept, definition, and importance of edible and therapeutic insects.
2. History and origin of insects as food, feed and medication.
3. Important insect species and insect products consumed.
4. Edible insect ecology, conservation and management of edible insect resources.
5. Environment and insect rearing.
6. Nutritional composition and role of insects in food security.
7. The concept and definitions of Insect farming.
8. Edible insect rearing techniques – I.
9. **Mid Semester Examination**

10. Edible insect rearing techniques – II.
11. Processing edible insects for food and feed.
12. Processing edible insects for feed.
13. Food safety and preservation.
14. Edible insects for livelihood security.
15. Insects used in Traditional Medicine.
16. Insects of therapeutic value in various parts of the world.
17. Regulatory issues in using insects as therapeutics and current status of edible insects. Current trends in entomophagy.

Practical

1. Survey on edible insects.
2. Identification of edible insects.
3. Survey on therapeutic insects.
4. Identification of therapeutic insects.
5. Collection and preservation of edible insects.
6. Collection and preservation of therapeutic insects.
7. Rearing techniques of edible insect species.
8. Rearing techniques oftherapeutic insect species.
9. Natural and artificial diet in rearing edible and therapeutic insects.
10. Influence of abiotic factors on the growth of edible insects.
11. Influence of biotic factors on the growth of edible insects.
12. Influence of abiotic factors on the growth of therapeutic insects.
13. Influence of biotic factors on the growth of therapeutic insects.
14. Harvesting techniques of edible insects from natural environment.
15. Analysis of proximate elemental composition.
16. Antioxidant and anti-nutritionalproperties of edible insects.
17. Preservation of edible and therapeutic insects.

Course outcome

CO 1: Knowledge on insects for edible purpose.
CO 2: Knowledge on insects for therapeutic use.
CO 3: Knowing the nutritional composition of edible insects.
CO 4: Knowledge on the biochemicals responsible for therapeutic use.
CO 5: Acquire techniques of farming and processing insects for edible and therapeutic use.

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	-	1
CO 2	3	3	1	-	1
CO 3	3	3	1	2	2
CO 4	3	3	2	2	2
CO 5	3	3	2	2	2

Suggested Reading

1. Halloran A, Flore R, Vantomme P and Roos N 2018. *Edible insects in sustainable food systems*. Springer International, Netherlands. 479 p.
2. Hassan Ajayi Shindi. 2021. *Entomophagy Studies: Comparative analysis on edible insects and conventional meat*. Lambert Academic Publishing, Germany. 92 p.
3. Mitsuhashi, J. 2021. *Edible Insects of the World*. CRC Press, London. 296 p.
4. Sogari, G., Mora, C. and Menozzi, D. 2019. *Edible Insects in the Food Sector*. Springer Nature, Switzerland. 120 p.
5. 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.

E-resources

- https://www.fao.org/3/i3253e/i3253e00.htm
- https://www.fao.org/edible-insects/en/
- http://www.entomophagy.org/
- https://allianceforscience.cornell.edu/blog/2018/07/edible-insects-overcoming-ick-factor/
- https://cisr.ucr.edu/entomophagy-eating-insects

ENT 522Medical and Veterinary Entomology (1+1)

Course outcome

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

Theory

Unit I: Introduction

Introduction to medical, veterinary and forensic entomology; Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; pests of medical and veterinary importance.

Unit II: Flies

Mosquito taxonomy, biology, and behavior; mosquito transmitted diseases: EEE, VEE, SLE, yellow fever,malaria, filariasis, mansonellosis,mosquito surveillance, horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary importance, onchocerciasis.Tsetseflies;moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae).

Unit III: Lice and fleas

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

Unit IV: Ticks, bugs and other insects

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

Unit V: Management of pests of medical and veterinary importance

Management strategies for pests of medical and veterinary importance – Chemical, non-chemical, ecological and genetic manipulations, Community efforts in managing these pests.Current trends in medical and veterinary entomology.

Practical

Identification of arthropod Classes, Orders and Families of medical and veterinaryimportance;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.

Lecture Schedule

1. Introduction to medical, veterinary and forensic entomology.
2. Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; pests of medical and veterinary importance.
3. Mosquito taxonomy, biology, and behavior.
4. Mosquito transmitted diseases: EEE, VEE, SLE, yellow fever; malaria; filariasis, mansonellosis.
5. Mosquito surveillance.
6. Horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies.
7. Black flies of medical and veterinary Importance, onchocerciasis. tsetse flies; moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae).
8. Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, etc.; mites: rickettsial pox.
9. **Mid Semester Examination**
10. Mites and acariasis: mange, scabies, chiggers; spiders and scorpions.
11. Fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus.
12. Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia.
13. True bugs (Hemiptera): kissing bugs and bedbugs; chagas disease.
14. Lepidoptera and Hymenoptera of medical and veterinary importance.
15. Management strategies for pests of medical and veterinary importance – Chemical strategies.

16. Management strategies for pests of medical and veterinary importance – non-chemical, ecological and genetic manipulations.
17. Community efforts in managing these pests. Current trends in medical and veterinary entomology.

Practical Schedule

1. Collection and Identification of important mosquito species from different ecosystems – I.
2. Collection and Identification of important mosquito species from different ecosystems – II.
3. Identification of breeding sites of different mosquito species – I.
4. Identification of breeding sites of different mosquito species – II.
5. Collection and Identification of other Dipteran vectors of medical and veterinaryimportance.
6. Collection and Identification of lice vectors of medical and veterinaryimportance.
7. Collection and Identification of mite species of medical and veterinaryimportance.
8. Collection and Identification of flea species of medical and veterinaryimportance.
9. Collection andIdentification of tick species of medical and veterinaryimportance.
10. Collection andIdentification of bug species of medical and veterinaryimportance.
11. Collection andIdentification of Lepidopteran and Hymenopteran species of medical and veterinaryimportance.
12. Studies on Chemical management of vectors – I.
13. Studies on Chemical management of vectors – II.
14. Studies on Non-Chemical management of vectors – I.
15. Studies on Non-Chemical management of vectors – II.
16. Ecological management of insect vectors of medical and veterinary importance.
17. Visit to Vector Control centres / laboratories / institutes.

Course outcome

CO 1: Knowledge on medical, veterinary and forensic entomology

CO 2: Expertise on taxonomy, biology, and behavior of pests of medical and veterinary importance

CO 3: Understanding the way of disease transmission of arthropod vectors

CO 4: Skill in management options of arthropod vectors

CO 5: Perception on community efforts in managing arthropod vectors

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	1	1
CO 2	3	3	2	1	2
CO 3	3	3	3	2	1
CO 4	3	3	3	2	3

CO 5	3	3	1	2	3

Suggested Reading

1. David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.
2. Gullan PJ and Cranston PS. 2010. *The Insects: An Outline of Entomology*. 4th Edition, WileyBlackwell, West Sussex, UK & New Jersey, US.
3. Mike Service. 2012. *Medical Entomology for Students*. Cambridge University Press, London.
4. Mullen G and Durden LA. 2018. *Medical and Veterinary Entomology*, 3rd Edition, Academic Press.
5. Richard Russell, C., Domenico Otranto and Richard Wall. 2013. *The Encyclopedia of Medical and Veterinary Entomology*, CABI, London.

E-resources

- https://web.natur.cuni.cz/parasitology/vyuka/LekEnt_CV/Mullen%20and%20Durden%20-%20Medical%20and%20Veterinary%20Entomology%202019.pdf
- https://health.nt.gov.au/professionals/centre-for-disease-control/cdc-programs-and-units/medical-entomology
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7716807/
- https://extension.entm.purdue.edu/publichealth/
- https://www.veterinaryentomology.org/

ENT 523 – ForestEntomology(2+0)

Course Objectives

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

Theory

Unit I: Introduction

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.History of tropical forest entomology.

Unit II: Insects in Forest Ecosystems

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: Forests pests

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: Ecology of pests in forest ecosystem

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 pests in forest ecosystem

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.Location-specific case studies. Current trends in forest entomology.

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 insect pests;Fire control methods and devices;Familiarization with the meteorological and plant protection equipment, applicationof pesticides and bio-control agents in the management of insect pests in nurseries and plantations.

Theory Schedule

1. Introduction to forestry in the tropics.
2. Characteristics and types of tropical forests.
3. Management of tropical forests and the problems in their management.
4. Plantation forestry: beginnings, expansion and current status.
5. History of tropical forest entomology.
6. Structural and functional diversity of forest insects.
7. The feeding guilds of forest insects.
8. Concept of pests in forest environment.
9. Ecology of insects in forest environment.
10. Concept and functioning of ecosystem.
11. 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.
12. Lepidopteran insect pests in natural forests, their incidence and outbreaks.
13. Coleopteran insect pests in natural forests, their incidence and outbreaks.

14. Hemipteran insect pests in natural forests, their incidence and outbreaks.
15. Hymenopteran insect pests in natural forests, their incidence and outbreaks.
16. Insect pests in forest plantations.
17. **Mid Semester Examination**
18. Insect pests in forest plantation nursery and saplings.
19. Pests of older plantations and their impact.
20. Insect pests of stored timber, categories of wood destroying insects and their damage: termites and beetles.
21. Population dynamics, characteristics of population growth, factors affecting population growth, principles governing population dynamics.
22. Types and causes of forest insect outbreaks.
23. General issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis.
24. Pest problems in plantations of indigenous *vs* exotic species.
25. Pest problems in monocultures *vs* mixed plantations.
26. Historical development and present status of tropical forest pest management.
27. Overview of preventive measures in forest pest management.
28. Overview of Remedial measures in forest pest management – Chemical measures.
29. Scope of aerial spraying / drone spraying in forest pest management.
30. Overview of Remedial measures in forest pest management –Non-Chemical measures.
31. Unique features of forest pest management.
32. Constraints to forest pest management in the tropics.
33. Guidelines for the practice of forest pest management in the tropics.
34. Location-specific case studies. Current trends in forest entomology.

Course outcome

CO 1: Acquire knowledge of insect pests of forest nurseries,forests and plantations
CO 2: Expertise in identifying their nature of damage
CO 3: Knowledge on the life history traits
CO 4: Proficiency in effective management of forest pests
CO 5: Knowledge of pestiferous insectsof stored timber, hide and other forest produce

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	1	1
CO 2	3	3	1	2	1
CO 3	3	3	1	1	1
CO 4	3	3	1	2	1
CO 5	3	3	1	1	1

Suggested Reading

1. Jha LK and Sen Sarna PK. 1994. *Forest Entomology*. Ashish Publishing House, Delhi.

2. Nair KSS. 2007. *Tropical Forest Insect Pests: Ecology, Impact, and Management*, Cambridge University Press, Edinburgh/ New York.
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ENT 512 Insect Vectors of Plant Pathogens(1+1)

Course Objective

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

Theory

Unit I: Introduction

History of developments in the area of insects as vectors of plant pathogens.Phytotoxemia and disease - fundamentals of disease transmission by insect vectors mouth parts and feeding processes of important insect vectors.

Unit II: Insect Vectors

Important insect vectors and their characteristics; Efficiency of transmission. Influence of abiotic and biotic factors on disease transmission by insects.

Unit III: Bacterial and fungal pathogens

Transmission of bacterial and fungal pathogens - infections through pollen, wounds, exudates, feeding and oviposition by vectors.

Unit IV: Viral, phytoplasmal and spiroplasmal pathogens

Transmission of plant viruses by aphids, whiteflies, mealy bugs, psyllids, beetles, thrips, mites and nematodes. Relation between viruses and their vectors. Transmission of phytoplasma, spiroplasma by leaf hoppers and plant hoppers.

Unit V: Ecology & management of insect vectored plant diseases

Beneficial and lethal effects of pathogens on vectors, influence of symbiotes on pathogen transmission by vectors. Ecological aspects of plant disease transmission by vectors – survey of insect vectors, alternate hosts including wild/weed plant species as reservoirs of disease pathogens, indicator plants, Epidemiology and management of insect transmitted diseases through vector management– principles and practices – novel approaches.

Practical

Identification and histology of insect induced galls, studying the mouth parts of important insect vectors, Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; identification of symptoms of vector transmitted plant diseases, Culturing and handling of vectors; demonstration of virus transmission through mechanical methods and vectors- aphids, leafhoppers and whiteflies;Estimating vector transmission efficiency, studying vector-virus host interaction.

Theory lecture schedule

1. History of developments in the area of insects as vectors of plant pathogens.
2. Phytotoxemia and disease.
3. Fundamentals of disease transmission by insect vectors,Classification of plant diseases based on transmission by insect vectors.
4. Feeding process of important insect vectors.
5. Hemipterans, Thrips, other insects, mites and nematodes as vectors of plant diseases.
6. Influence of abiotic factors on disease transmission by insect vectors.
7. Influence of bioticfactors on disease transmission by insect vectors.
8. Transmission of bacterial and fungal pathogens by insects.
9. **Mid-semester examination**
10. Transmission of plant viruses by insectsand Virus - vector relationship.
11. Transmission of phytoplasma by leaf hoppers and plant hoppers.
12. Beneficial and lethal effects of pathogens on vectors and endosymbionts.
13. Ecological aspects of plant disease transmission by vectors.
14. Survey of insect vectors.
15. Alternate hosts including wild/weed plant species as reservoirs of disease pathogens – Indicator plants.
16. Epidemiology of insect transmitted diseases.
17. Vector management - principles and practices, novel approaches. Current trends in vector entomology.

Practical Schedule

1. Identification of insect and mite induced galls & gall forming insects.
2. Histology of insect and / or mite induced galls-I.
3. Histology of insect and / or mite induced galls-II.
4. Sectioning and studying the mouth parts of important insect vectors- I.
5. Sectioning and studying the mouth parts of important insect vectors- II.
6. Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes.
7. Identification of symptoms of vector transmitted plant diseases.
8. Culturing and handling of vectors.
9. demonstration of virus transmission through mechanical methods- I.
10. demonstration of virus transmission through mechanical methods- II.
11. Demonstration of virus transmission through vectors- rice tungro virus- I.
12. Demonstration of virus transmission through vectors- rice tungro virus- II.

13. Demonstration of virus transmission through vectors- bhendi vein clearing virus- I.
14. Demonstration of virus transmission through vectors- bhendi vein clearing virus- II.
15. Demonstration of phytoplasma transmission through vectors.
16. Estimating vector transmission efficiency.
17. Studying vector-virus host interaction.

Course Outcome

CO 1: Proficiency in identifyinginsect vectors of plant pathogens.
CO 2: Acquire knowledge on the role abiotic and biotic factors on disease transmission.
CO 3: Competency in identifying epidemiology of insect transmitted diseases.
CO 4: Learning the Virus - vector relationship.
CO 5: Expertise in Vector management.

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	2	1
CO 2	3	3	1	2	1
CO 3	3	3	1	2	1
CO 4	3	3	1	2	1
CO 5	3	3	1	1	1

Suggested Reading

1) Alan Weller and Dover Pictura .2011. *Insects Vector Designs*. Academic Press, London.
2) Basu AN. 1995. *Bemisiatabaci*(Gennadius) - *Crop Pest and Principal Whitefly Vector of Plant Viruses.* Oxford & IBH, New Delhi.
3) Harris KF and Maramarosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.
4) Maramorosch K and Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.
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ENT 513 –Principlesof Acarology (1+1)

Course Objective

- To acquaint the students with external morphology of different groups of mites, identification of commonly occurring families of plant associated mites andmite pests of crops
- To familiarize the students on the management of mites

Theory

Unit I: History of Acrology

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: Morphology, biology and taxonomy of Acari

Introduction to morphology and biology of mites and ticks. Broad classification - major orders and important families of Acari including diagnostic characteristics.

Unit III: Sampling and culturing of mites

Estimation of populations; sampling and extraction methods for soil arthropods.
Culturing of phytophagous, parasitic and predatory mites.

Unit IV: Mites as pests

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.

Unit V: Management of mites

Management of mites using acaricides, phytoseiid predators, fungal pathogens, etc. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management. Current trends in acrology.

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.

Lecture Schedule

1. History of Acarology; importance of mites as a group; their habitat.
2. Collection and preservation of mites.
3. Soil arthropods and their classification, habitats and their identification.
4. Morphology of mites and ticks.
5. Biology of mites and ticks.
6. Broad classification major orders and important families of Acari including diagnostic characteristics.
7. Estimation of populations.
8. Sampling and extraction methods for soil arthropods.
9. **Mid Semester Examination**
10. Culturing of phytophagous mites.
11. Culturing of parasitic mites.
12. Culturing of predatory mites.
13. Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops.
14. Mite pests in polyhouses, mite pests of stored products and honeybees.
15. Management of mites using acaricides.
16. Phytoseiid predators, fungal pathogens, etc.
17. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management. Current trends in acarology.

Practical Schedule

1. Identification of mites from plants.
2. Identification of mites from soil.
3. Identification of mites from animals.
4. Extraction of mites from soil.
5. Collection of mites fromplants.
6. Collection of mites from stored products.
7. Preparation of mounting media and slide mounts.
8. General external morphology of mites.
9. Identification and external morphology of Tetranychid mites.
10. Identification and external morphology of Tenuipalpid mites.
11. Identification and external morphology of Eriophyidmites.
12. Identification and external morphology of Tarsonemidmites.
13. Identification and external morphology of predatory mites.
14. Identification of mite pests in polyhouses.
15. Identification of miteson honeybees.
16. Studying different rearing techniques for mites.
17. Studies on management mites.

Course outcome

CO 1: Proficiency in identifying mites up to family level.

CO 2: Acquire knowledge of mite pests of cultivated crops.
CO 3: Competency in identifying the nature of damagecaused by mites in various crops.
CO 4: Learning the culturing techniques of mites.
CO 5: Expertise in suggesting effective management techniques for mites.

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	1	1
CO 2	3	3	1	1	2
CO 3	3	3	1	1	1
CO 4	3	3	3	3	2
CO 5	3	3	2	3	2

Suggested Reading

1. Anderson JM and Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.
2. Chhillar BS, Gulati R and Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.
3. Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley and Sons, New York.
4. Gerson U and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman and Hall, NewYork.
5. Gupta SK. 1985. *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta.
6. Gwilyn O and Evans GO. 1998. *Principles of Acarology*. CABI, London.
7. Jeppson LR, Keifer HH and Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.
8. QiangZhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control*. CABI, London.
9. Sadana GL. 1997. *False Spider Mites Infesting Crops in India.* Kalyani Publishers House, New Delhi.
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ENT 514 Vertebrate Pest Management (1+1)

Course Objective

- To impart knowledge on vertebrate pests such as birds, rodents, mammals and others on different crops.
- To study their biology, damage and management strategies.

Theory

Unit I: Introduction

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

Unit II: Birds

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: Rodents

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: Higher vertebrates

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

Unit V: Integrated Management of vertebrate pests

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. Current trends in vertebrate pest management.

Practical

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

Theory Schedule

1. Introduction to vertebrate pests of different crops
2. Biology of major rodent pests.
3. Biology of major bird pests.
4. Biology of important pestiferous mammals.
5. Bio-ecology of birds of agricultural importance, patterns of bird pest damage and assessment.
6. Roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.
7. Bio-ecology of rodents of agricultural importance.
8. patterns of pest damage and assessment, burrowing pattern and habitat of rodents.

9. **Mid-Semester Examination**
10. Management of pestiferous rodents.
11. Bio-ecology of higher vertebrates of agricultural importance.
12. patterns of damage and assessment, their habitat.
13. management of pestiferous vertebrates.
14. Integrated management of vertebrate pests - physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants).
15. Integrated management of vertebrate pests - biological (predators, parasites).
16. Integrated management of vertebrate pests – Ecological (cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods).
17. Integrated management of vertebrate pests - Operational practices- baiting, equipments and educative programmes. Current trends in vertebrate pest management.

Practical Schedule

1. Identification of important rodents.
2. Identification of important pestiferous birds.
3. Identification of important vertebrate pests.
4. Studies on food preference and hoarding behaviour of rodents.
5. Studies on food preference and hoarding behaviour of pestiferous birds.
6. Studies on food preference and hoarding behaviour of vertebrate pests.
7. Studies on social behaviour of rodents.
8. Studies on social behaviour of pestiferous birds.
9. Studies on social behaviour of vertebrate pests.
10. Studies on assessment of damage caused by rodents.
11. Studies on assessment of damage caused by pestiferous birds.
12. Studies on assessment of damage caused by vertebrate pests.
13. Studies on estimation of population of rodents.
14. Studies on estimation of population of pestiferous birds.
15. Studies on estimation of population of vertebrate pests.
16. Vertebrate pest management - Preventive measures.
17. Vertebrate pest management - Curative measures.

Course outcome

CO 1: Knowledge on vertebrate pest diversity.
CO 2: Expertise on methodology in assessing their damage.
CO 3: Knowledge on life history and behaviour of vertebrate pests.
CO 4: Skills in assessing vertebrate pest abundance.
CO 5: Proficiency in constructing effective management techniques.

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	1	1
CO 2	3	3	3	2	1
CO 3	3	3	1	2	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3

Suggested Reading

1. Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay.
2. Fitzwater WD and Prakash I. 1989. *Handbook of Vertebrate Pest Control.* ICAR, New Delhi.
3. Prakash I and Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.
4. Prakash I and Ghosh RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.
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ENT 515 Techniquesin Plant Protection(1+2)

Course Objective

- To acquaint the students with appropriate use of plant protection equipment
- To impart skills in techniques related to microscopy, computation, pest forecasting, etc.

Theory

Unit I: Plant protection equipment

Types of plant protection equipment – uses, principles, specifications, efficiency, maintenance, BIS standards.

Unit II: Application of pesticides

Application through seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water;Use of drones in pesticide application.

Unit III: Non-chemical techniques

Field release of bio-control agents, cultural, physical, mechanical measures in pest management.

Unit IV: Molecular techniques

Principles of light, transmission and scanning electron microscopy; Use of spectrophotometer and molecular weight determination using SDS/ PAGE; Use of tissue culture techniques in plant protection; use of Potter's tower, microtomy.

Unit V:Novel tools in plant protection

Computer application for predicting/ forecasting pest attack and identification – GIS and Remote sensing techniques, use of drones in monitoring pests. Current trends in plant protection.

Practical

Pest control equipment, principles, operation, maintenance, selection, andapplication of pesticides;Release of bio-control agents;Seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticideapplication through irrigation water;Application of drones in plant protection;Soil sterilization, solarization, deep ploughing, flooding, techniques to check thespread 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 usingspectrophotometer and molecular weight determination using SDS/ PAGE;Use of tissue culture techniques in plant protection;Computer application for predicting/ forecasting pest attack and identification.

Theory Schedule

1. Types of plant protection equipment – uses, principles, specifications.
2. Efficiency, maintenance, BIS standards of plant protection equipment.
3. Application through seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water.
4. Application of drones in pesticide application.
5. Field release of bio-control agents.
6. Cultural measures in pest management.
7. Physical measures in pest management.
8. Mechanical measures in pest management.
9. **Mid Semester Examination**
10. Principles of light microscopy.
11. Principles of transmission electron microscopy.
12. Principles of scanning electron microscopy.
13. Use of spectrophotometer.
14. Molecular weight determination using SDS/ PAGE.
15. Use of tissue culture techniques in plant protection.
16. Computer application for predicting/ forecasting pest attack and identification.

17. Use of GIS and Remote sensing techniques,Use of drones in monitoring pests, Other current trends in plant protection.

Practical Schedule

1. Working mechanism of manual sprayers.
2. Working mechanism of power sprayers.
3. Working mechanism of manual dusters.
4. Working mechanism of power dusters.
5. Working mechanism of special plant protection equipment.
6. Types of nozzles.
7. Care and maintenance of plant protection equipment.
8. Pesticide Application through seed dressing.
9. Practicing seed and root-dip treatment.
10. Practicing pesticide application through dusting.
11. Practicing pesticide application through spraying.
12. Practicing pesticide application through irrigation water.
13. Use of drones in pesticide application.
14. Practicing Field release techniques for bio-control agents– Parasitoids.
15. Practicing Field release techniques for bio-control agents– Predators.
16. PracticingCultural measures in pest management – I.
17. Practicing Cultural measures in pest management – II.
18. Practicing Physical measures in pest management – I.
19. Practicing Physical measures in pest management – II.
20. Practicingmechanical measures in pest management– I.
21. Practicing mechanical measures in pest management – II.
22. Practicinguse of traps in pest management.
23. Studying the principles of light microscopy.
24. Studying the Principles of transmission electron microscopy.
25. Studying the Principles of scanning electron microscopy.
26. Studying the Use of spectrophotometer.
27. Molecular weight determination using SDS/ PAGE.
28. Use of tissue culture techniques in plant protection.
29. Practicing the use of Potter's tower.
30. Practicing the use of microtome.
31. Computer application for predicting/ forecasting pest attack and identification.
32. Use of GIS and Remote sensing techniques.
33. Use of drones in monitoring pests.
34. Visit to plant protection equipment service centres.

Course outcome

CO 1: Gaining thorough knowledge on plant protection equipment.
CO 2: Practical skill on all the plant protection techniques.
CO 3: Expertise in microscopy, microtome,Potter's tower etc.
CO 4: Develop skills in predicting/ forecasting pest incidence.

CO 5: Analysing the scope and limitations of drones in plant protection.

CO- PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	2	2	1
CO 2	3	3	2	2	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3

Suggested Reading

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2. Arbind Kumar Rai and Ram Kumar. 2019. *Plant Protection: Modern Techniques*. Biotech Books, New Delhi, India.
3. Chattopadhyay, S.B. 2018. Principles and Procedures of Plant Protection, Oxford & IBH Publishing, New Delhi, India.
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ENT 516 – Apiculture(1+2)

Course Objective

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

Theory

Unit I: Morphology and biology of bees

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: Bee keeping

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.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 III: Pests and disease of bees

Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptomsof 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; diseases of bees - ecology, nature and symptoms of damage, management tactics.

Unit IV: Bee products

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

Unit V: Ecological issues

Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees. Impact of intensive farming. Urbanization and bees. Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops. Current trends in apiculture.

Practical

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

Lecture Schedule

1. Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races.
2. 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.
3. Bee pheromones; Honey bee communication.
4. Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment.
5. 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.
6. 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.
7. Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptoms of damage, management tactics.
8. Wax moths, wasps and ants – biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; diseases of bees - ecology, nature and symptoms of damage, management tactics.
9. **Mid Semester Examination**
10. Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment.
11. Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling.
12. Apitherapy; Value addition of hive products; Development of apiculture project.
13. Pesticide poisoning to honey bees, signs and protection.
14. Protocols in evaluation of pesticide toxicity to honey bees.
15. Impact of intensive farming.
16. Urbanization and bees.
17. Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.Current trends in apiculture.

Practical Schedule

1. Morphology of honey beecastes – I.
2. Morphology of honey beecastes – II.
3. Dissection of mouthparts of honey bees.
4. Study of digestive and respiratory systems of honey bees.

5. Reproductive adaptations in different castesof honey bees.
6. Bee keeping appliances – I.
7. Bee keeping appliances – II.
8. Recording of colony performance.
9. Seasonal bee husbandry practices.
10. Swarming, queenlessness, swarming, laying workers menaces, etc. and theirremedies.
11. Innovative techniques in mass queen bee rearing.
12. Selection and breeding of honeybees.
13. Instrumental insemination; formulation of artificial diets and their feeding.
14. Harvesting and processing of honey.
15. Value addition in honey – I.
16. Value addition in honey – II.
17. Production technologies for various hive products.
18. Bee enemies and their management.
19. Bee diseases and their management.
20. Studies on bee pasturage – I.
21. Studies on bee pasturage – II.
22. Recording pollination efficiency– I.
23. Recording pollination efficiency – II.
24. Application of various models for determining pollination requirement of crop.
25. Developing a beekeeping project.
26. Studies on apitherapy.
27. Studying of rock bee.
28. Studying of Italian bee.
29. Studying of mosquito bee characters.
30. Studying of mosquito bee rearing – I.
31. Studying of mosquito bee rearing – II.
32. Studies on migratory bee keeping.
33. Impact of pesticides on honey bees.
34. Visit to commercial apiaries.

Course outcome

CO 1: Gaining thorough knowledge on bee biology and physiology.
CO 2: Practical skill on all the techniques of bee keeping.
CO 3: Proficiency in insect pest pests and diseases of bees and their management.
CO 4: Develop entrepreneurial skills for apiculture.
CO 5: Analysing the scope and limitations of apiculture and guide farmers.

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	1	2
CO 2	3	3	3	1	2
CO 3	3	3	2	3	2
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3

Suggested Reading

1. AbrolDP and Sharma D. 2009. *Honey Bee Mites and Their Management.* Kalyani Publishers, New Delhi, India.
2. Abrol DP.2009. *Honey bee Diseases and Their Management*. Kalyani Publishers, New Delhi, India.
3. Abrol DP. 2010. *Bees and Beekeeping in India*. Kalyani Publishers, New Delhi, India.
4. Abrol DP. 2012. *Pollination Biology: Biodiversity Conservation and Agricultural Production.* Springer.
5. Atwal AS. 2000. *Essentials of Beekeeping and Pollination*. Kalyani Publishers, New Delhi, India.
6. Dharm Singh. 2020. Commercial Beekeeping, Scientific Publishers, Jodhpur, India. 352 p.
7. Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. *Mass Multiplication of Honey Bee Colonies.* ICAR, New Delhi, India.
8. Holm E. 1995. *Queen Rearing Genetics and Breeding of Honey Bees.*Gedved, Denmark.
9. Mishra RC. 1995. *Honey Bees and their Management in India.* I.C.A.R., New Delhi, India.
10. Rahman, A. 2017. *Apiculture in India*, ICAR, New Delhi

E-resources

- https://www.britannica.com/topic/beekeeping
- https://vikaspedia.in/agriculture/farm-based-enterprises/bee-keeping-1/about-bee-keeping
- https://msme.gov.in/sites/default/files/Beekeeping.pdf
- https://krishijagran.com/agripedia/beekeeping-in-india-a-complete-guide-to-beekeeping-for-beginners/
- https://bees.caes.uga.edu/bees-beekeeping-pollination/getting-started-topics/getting-started-beekeeping-equipment.html

ENT 517 –Sericulture(1+2)

Course Objectives

- To familiarize the students with skills in silk worm rearing, production and management.
- To explain entrepreneurial opportunities in sericulture.

Theory

Unit I: History

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

Unit II: Host plant cultivation

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: Kinds silkworms

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 of silkworms

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 processing

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.Current trends in sericulture.

Practical

Morphology of mulberry plants;Identification of popular mulberry genotypes;Nursery bed and main field preparation;Planting methods;Identification of nutrient deficiency symptoms;Identification of weeds;Pruning and harvesting methods;Identification of pests and diseases of mulberry, Hosts of Eri, Tasar, Muga silkworms- Nursery and pruning techniques – Intercultural operations. Morphology of silkworm – Identification of races – Dissection of mouth parts andsilk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – 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 – Value addition and Economics of silkworm rearing.

Theory Schedule

1. History of Sericulture, importance, organizations involved in sericulture activities,
2. Silkworm types, distribution, area and silk production.
3. Mulberry species, ecological requirements, cultivation, improved varieties, propagation methods, sapling production, planting and pruning techniques.
4. Pest and diseases, management strategies; intercropping, water and weed management.

5. Food plants of eri silkworm, castor cultivation, intercultural operations, nutrient and water management; method of harvest.
6. Host plants of Tasar, nursery and cultivation,selection of seed, soaking and heap making, pruning techniques.
7. Food plants of Muga silkworm, Som and Soalu propagation methods; nursery techniques; intercultural operations and weed management.
8. Silkworm origin – classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races –multivoltine and bivoltine races – cross breeds – bivoltine hybrids.
9. **Mid Semester Examination**
10. Races and hybrids of mulberry, eri, tasar and muga silkworm.
11. Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.
12. Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods.
13. Chawki rearing, feeding, cleaning and spacing, Rearing of late age worms, feeding, cleaning, spacing and moulting care.
14. Mountages, cocoon harvesting and marketing.
15. Pests and diseases of silkworms and their management.
16. Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines.
17. Value addition in sericulture, Economics of sericulture.Current trends in sericulture.

Practical Schedule

1. Morphology of mulberry plants.
2. Identification of popular mulberry genotypes.
3. Nursery bed and main field preparation.
4. Mulberry Planting methods.
5. Identification of nutrient deficiency symptoms.
6. Identification of weeds.
7. Pruning and harvesting methods.
8. Identification of pests and diseases of mulberry.
9. Host plants of Eri, Tasar and Muga silkworms –Nursery and pruning techniques – Intercultural operations.
10. Morphology of silkworm.
11. Identification of silkworm races.
12. Dissection of mouth parts andsilk glands.
13. Practicing sex determination in silkworm larva and pupa.
14. Rearing House facility.
15. Rearing Equipment.
16. Practicing egg incubation methods.
17. Chawkirearing – feeding, cleaning and spacing.

18. Later age rearing – feeding, cleaning and spacing.
19. Mountages and mounting of silkworms.
20. Harvesting of cocoons and preservation/ transport.
21. Identification of pests of mulberry silkworm.
22. Identification of diseases of mulberry silkworm.
23. Practicing disinfection of rearing house and equipment.
24. Silkworm egg production technology.
25. Tasar Silkworm rearing methods.
26. Eri Silkworm rearing methods– I.
27. Eri Silkworm rearing methods – II.
28. Muga silkworm rearing methods.
29. Pests and diseases of non-mulberry silkworms.
30. Visit to grainages.
31. Visit to cocoon markets.
32. Visit to silk reeling centres.
33. Value addition in silkworm rearing.
34. Economics of silkworm rearing.

Course outcome

CO 1: Gaining thorough knowledge on silkworm morphology, races and biology.
CO 2: Practical skill on all the techniques of rearing and silk production.
CO 3: Proficiency in insect pest pests and diseases of silkworm and their management.
CO 4: Develop entrepreneurial skills for sericulture.
CO 5: Analysing the scope and limitations of sericulture and guide farmers.

CO–PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	3	3	1	1	1
CO 2	3	3	3	3	2
CO 3	3	3	3	3	2
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3

Suggested Reading

1. Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.
2. 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.
3. Jolly MS, Sen SK, Sonwalkar TN and Prasad GK. 1980. Non–mulberry Silks. FAO Agicultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.
4. 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.

5. Mohanty PK. 2003. Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, 197 p.
6. Nataraju B, Sathyaprasad K, Manjunath D and Kumar A. 2005. Silkworm crop protection. CSB, Bangalore. 412 pp.
7. 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.
8. Sandhya Rani, G. 2006. Women In Sericulture. Discovery Publishing House. New Delhi, 265p.
9. Sunil P Trivedi; Kamal Jaiswal; B N Pandey and P N Pandey. 2009. Indian Sericulture: Past, Present and Future. Alfa Publications, New Delhi, 297 p
10. Tribhuvan Singh and Saratchandra B. 2004. Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 p.

E-resources

- www.silkwormgenomics.org
- www.silkboard.com
- www.silkgermplasm.com
- www.csrtimys.res.in
- https://vikaspedia.in/agriculture/farm-based-enterprises/sericulture/sericulture-in-india

COMMON COMPULSORY COURSES

PGS 501 - LIBRARY AND INFORMATION SERVICES (0+1)

Objective

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

Practical

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

Practical Schedule

1. Introduction to library and its services
2. Role of libraries in education, research and technology transfer;
3. Classification systems and organization of library
4. Sources of information- Primary Sources, Secondary Sources and Tertiary Sources
5. **First test**
6. Intricacies of abstracting and indexing services
7. Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.);
8. Tracing - information from reference sources; Literature survey
9. **Mid- Semester**
10. Citation techniques/Preparation of bibliography;
11. Use of CD-ROM Databases,
12. Online Public Access Catalogue and other computerized - library services
13. Online Public Access Catalogue and other computerized - library services
14. Use of Internet including search engines and its resources
15. Use of Internet including search engines and its resources
16. e-resources access methods.
17. Final practical examination

PGS 502 - TECHNICAL WRITING AND COMMUNICATION SKILLS (0+1)

Objective

- To equip the students with skills *Viz.*, writing of dissertations, research papers, etc. and to communicate and articulate in English

Practical

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. Proof reading. Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Structure 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.

Practical schedule

1. Grammar (Tenses, parts of speech)
2. Grammar (clauses, punctuation marks)
3. Error analysis (Common errors); Concord; Collocation;
4. Phonetic symbols and transcription;
5. **First test**
6. Accentual pattern: Weak forms in connected speech
7. Participation in group discussion, Facing an interview; presentation of scientific papers.
8. Technical Writing- Various forms of scientific writings- theses, technical papers
9. **Mid -semester examination**
10. Technical Writing- reviews, manuals
11. Structure of thesis and research communications
12. Writing of abstracts, summaries, précis, citations etc
13. Commonly used abbreviations in the theses and research communications
14. Illustrations, photographs and drawings with suitable captions
15. Pagination, numbering of tables and illustration, numbers and dates in scientific write-ups
16. Editing and proof-reading, Writing of a review article.
17. Final practical examination

Suggested Readings

1. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
2. Mohan K. 2005. Speaking English Effectively. MacMillan India.
3. Richard WS. 1969. Technical Writing. Barnes & Noble.
4. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. Abhishek.
5. Wren PC & Martin H. 2006. High School English Grammar and Composition. S.Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objectives

The objective of the course is to create awareness about intellectual property rights in agriculture. The course deals with management of patents, trademark, geographical indications, copy rights, designs, plant variety protection and biodiversity protection. The students will be taught on the marketing and commercialization of intellectual properties.

Theory

Unit - I- World trade organization - introduction

World Trade Organization - Agreement on Agriculture (AoA) and Intellectual Property Rights (IPR) - importance of intellectual property management - IPR and economic growth - IPR and bio diversity - major areas of concern in intellectual property management - technology transfer and commercialization - forms of different intellectual properties generated by agricultural research.

Unit - II- Patent document

Discovery *versus* invention - patentability of biological inventions - procedure for patent protection - preparatory work - record keeping, writing a patent document, filing the patent document - types of patent application - patent application under the Patent Cooperation Treaty (PCT).

Unit - III- Plant genetic resources

Plant genetic resources - importance and conservation - sui generic system - plant varieties protection and farmers' rights act - registration of extinct varieties registration and protection of new varieties / hybrids / essentially derived varieties - dispute prevention and settlement - farmers' rights.

Unit - IV- Trademark

Trademark - geographical indications of goods and commodities - copy rightsdesigns - biodiversity protection.

Unit - V- Benefit sharing

Procedures for commercialization of technology - valuation, costs and pricing of technology - licensing and implementation of intellectual properties - procedures for commercialization - exclusive and non exclusive marketing rights - research exemption and benefit sharing.

Theory schedule

1. World Trade Organization - Agreement on Agriculture (AoA) and Intellectual Property Rights (IPR)
2. Importance of intellectual property management - IPR and economic growth - IPR and bio diversity
3. Major areas of concern in Intellectual property management - technology transfer and commercialization
4. Forms of different intellectual properties generated by agricultural research
5. **First test**
6. Discovery versus invention patentability of biological inventions

7. Procedure for patent protection, Preparatory work - record keeping, writing a patent document, filing the patent document
8. Types of patent application - patent application under the Patent Cooperation Treaty (PCT)
9. **Mid semester examination**
10. Plant genetic resources - importance and conservation
11. Sui generic system - plant varieties protection and farmers' rights act registration of extant varieties
12. Registration and protection of new varieties / hybrids / essentially derived varieties - dispute prevention and settlement - farmers' rights
13. Trade mark - geographical indications of goods and commodities - copy rights – designs ,Biodiversity protection,
14. Procedures for commercialization of technology - valuation, costs and pricing of technology
15. Licensing and implementation of intellectual properties - procedures for commercialization
16. Exclusive and non exclusive marketing rights - research exemption and benefit sharing
17. **Final practical examination**

Reference books

1. Arun Goyal and Moor Mohamed, 2001. *WTO in the New Millennium*, Academy of Business Studies, New Delhi.
2. Bilek Debroy, 2004. *Intellectual Property Rights*, BR World of books, New Delhi.
3. Ganguli, P., 2001. *Intellectual Property Rights - Unleashing the Knowledge Economy*. Tata McGraw Hill, New Delhi.
4. Narayanan, R., 2006. *Patent Law*, Eastern Law House, New Delhi.
5. Ramappa, T., 2000. *Intellectual Property Rights under WTO - Tasks before India*, Wheeler Publishing, New Delhi.

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

Objective

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

Practical

Unit-I-Safety measures and common laboratory equipment's

Safety measures while in labs; Handling of chemical substances; use of burettes, pipettes, measuring cylinders, flasks, separator funnel, condensers and micropipettes. Washing, drying and sterilization of glassware; drying of solvents/ chemicals.

Unit-II - Preparation of standard solutions

Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; preparations of different Agro-chemical doses in field and pot applications; preparation of solutions of acids; Neutralization of acid and bases; preparation of buffers of different strengths and pH values.

Unit-III-Use and handling of laboratory equipment's

Use and handling of vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath and water bath.

Unit-IV - Microscopy and media preparation

Use and handling of microscope and laminar flow-preparation of media-differential, selective and enriched media. Methods of sterilization –physical methods-dry and moist heat, cold, filtration and radiation, chemical methods and disinfectants.

Unit-V - In-vitro culture techniques

Description of flowering plants in botanical terms in relation to taxonomy- seed viability test-pollen fertility test-tissue culture media-composition of media-media preparation –instant media-aseptic manipulation-procedure for in vitro culture of explants-leaf bit-stem bit-anthers-pollen –microspores-ovule and embryo.

Practical schedule

1. Safety measures in labs and handling of chemical substances.
2. Common laboratory equipment's. Calibration and cleanliness of volumetric glass wares.
3. Methods of expressing strength of solutions.
4. Preparation of primary standard solutions and buffer solutions.
5. **First test**
6. Preparation of standard solutions for nutrient analysis of soil, plant and water.
7. Preparation of different Agro-chemical doses for field experiments, Preparation of buffer solutions,
8. Handling of instruments-vacuum pumps, thermometers, and magnetic stirrer.
9. **Mid semester Examination**
10. Handling of instruments-ovens, sand bath and water bath.
11. Handling and uses of microscopes and laminar flow.
12. Sterilization by physical methods and Sterilization by chemical methods.
13. Preparation of different media for culturing the micro-organisms.
14. Description of flowering plants-seed viability test and pollen fertility test.
15. Aseptic manipulations and media.
16. In vitro culture of different explants.
17. Final practical examination

References

1. Furr, A.K.2000.Handbook of laboratory safety. CRC press.
2. Jackson, M.L. 1997. Soil Chemical Analysis. Prentice Hall of India pvt. Ltd., New Delhi.
3. Prescott.L.M, Harley, P and Klein, A. 2003. Microbiology, 5th Edition, McGraw Hill, USA.
4. Gupta, P.K. 1997.Elements of Biotechnology, Rastogi Publications. Meerut.
5. Singh, B.D. 2005.Biotechnology, Expanding Horizons, Kalyani Publications, New Delhi.

e-Reference

1. Analytical chemistry vol.1 (pdf) www.freebook centre.net.
2. Micheal Zehfus Analytical chemistry www.free book centre.net.

3. Introduction to Instrumental Analytical Chemistry Roger Terril www.freebook centre.net.
4. Analytical Chemistry lecture notes sadhu malyadri centre.net.
5. Manfred Sietz and Andreas Sonnenberg. Short introduction into analytical chemistry www.freebook centre.net.

PGS 505 - AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

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

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.

Unit IV

Research prioritization and selection of research problem – Research planning - review of literature – setting of objectives and hypothesis – research design and techniques – data collection – analysis – formulation of tables – interpretation of results- Computer software in tabulation, presentation - Thesis writing – writing of research articles- projects and report writing – Formulation and preparation of research / scheme proposal – Impact factor and citation index - citation and references- Guidelines for oral / poster presentations – Internet in scientific research.

Unit V

Authorship and copy right – Plagiarism – Scientific misconduct – Falsification of research results, data fabrication – Peer review, informed consent attribution of authorship and adequacy of peer review publication process -Responsibility of society and self – Public interest in research, relevance to society and motivation - Conflict of interest, moral commitment – Social trends on research ethics, adequate codes of conduct to regulate research activity

Theory lecture schedule

1. History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment
2. National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR); International Agricultural Research Centres (IARC)
3. 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.
4. Research ethics: research integrity, research safety in laboratories
5. **First test**
6. Welfare of animals used in research, computer ethics, standards and problems in research ethics.
7. Concept and connotations of rural development, rural development policies and strategies.
8. 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.
9. **Mid semester examination**
10. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.
11. Research prioritization and selection of research problem – Research planning - review of literature – setting of objectives and hypothesis – research design and techniques
12. Data collection -– analysis – formulation of tables – interpretation of results- Computer software in tabulation and presentation
13. Thesis writing – writing of research articles- projects and report writing – Formulation and preparation of research / scheme proposal
14. Impact factor and citation index - citation and references- Guidelines for oral / poster presentations – Internet in scientific research.
15. Authorship and copy right – Plagiarism – Scientific misconduct – Falsification of research results, data fabrication – Peer review, informed consent attribution of authorship and adequacy of peer review publication process
16. Responsibility of society and self – Public interest in research, relevance to society and motivation - Conflict of interest, moral commitment
17. Social trends on research ethics, adequate codes of conduct to regulate research activity

Reference

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.

ANNEXURE-1

PROFORMA FOR FORMATION OF RESEARCH ADVISORY COMMITTEE

(**To be sent before the end of I Semester**)

1. Name of the student :

2. Enrolment number: Reg. No. :

3. Degree :

4. Subject :

5. Advisory Committee :

S.No.	Advisory Committee	Name, Designation and Department	Signature
1.	Chairperson		
2.	Members		
	Additional Member		
	Reasons for additional Member		

Professor and Head

Additional members may be included only in the allied faculty related to thesis research with full justification at the time of sending proposals (Program of research).

ANNEXURE-II

PROFORMA FOR CHANGE IN THE RESEARCH ADVISORY COMMITTEE

1. Name of the student :
2. Enrolment number: Reg. No.
3. Subject :
4. Degree :
5. Proposed Change :

Advisory Committee	Name and designation	Signature
a. Existing member		
b. Proposed member		

6. Reasons for change

Chairperson

Signature of Professor and Head

ANNEXURE-III

PROFORMA FOR OUTLINE OF RESEARCH WORK (ORW)
(To be sent before the end of I Semester)

1. Name :
2. Enrolment number: Reg. No.
3. Degree :
4. Subject :
5. Date of Joining :
6. Title of the research project :
7. Objectives :
8. Duration :
9. Review of work done :
10. Broad outline of work/methodology :
11. Semester wise break up of work :

Signature of student

Approval of the advisory committee

Advisory committee	Name	Signature
Chairperson		
Members		
1.		
2.		

Professor and Head

ANNEXURE-IV

PROFORMA FOR CHANGE IN OUTLINE OF RESEARCH WORK (ORW)

1. Name :

2. Enrolment number: Reg. No

3 Degree :

4 Subject

5 Reasons for change :

6 Proposed change in the approved Program of research:

7 Number of credits completed so far Under the approved program:

8 a. Whether already earned credits are to be retained or to be deleted:

b. if retained, justification:

Signature of the student

Approval of the Advisory Committee

Advisory committee	Name	Signature
Chairperson		
Members		
Intra		
Inter		

Professor and Head

ANNEXURE-V

DEPARTMENT OF _____

PROFORMA FOR EVALUATION OF SEMINAR

1. Name of the candidate :
2. Register Number :
3. Degree programme :
4. Semester :
5. Topic of the seminar and credit :
6. Distribution of marks

Distribution of marks	Max Marks				
i. Literature coverage	40				
ii. Presentation	30				
iii. Use of audio – visual aid	10				
iv. Interactive skills	20				
Total	100				
Name					
Designation		Chairperson	Intra Member	Inter Member	Aver age
Signature					

Grade point:

Head of the Department

ANNEXURE-VI

PROFORMA FOR REGISTRATION OF RESEARCH CREDITS

(**To be given during first week of semester**)

PART A: PROGRAM

Semester: Year: Date of registration:

1. Name of the student and
2. Enrolment number:/Reg. No.:
3. Total research credits completed so far:
4. Research credits registered during the semester:
5. Program of work for this semester (list out the Items of research work to be undertaken during the semester) :

Approval of advisory committee

Advisory committee	**Name**	**Signature**
Chairperson		
Members		
1. Intra		
2. Inter		

Professor and Head

Approval may be accorded within 10 days of registration

ANNEXURE-VII

PROFORMA FOR EVALUATION OF RESEARCH CREDITS

PART B EVALUATION

(**Evaluation to be done before the closure of Semester**)

Date of Commencement semester: Date of closure of semester:

Date of evaluation:

1. Name of the student
2. Enrolment number: Reg. No.:
3. Total research credits completed so far:
4. Research credits registered during the semester:
5. Whether the research work has been carried out as per the approved program:
6. If there is deviation specify the reasons :
7. Performance of the candidate : SATISFACTORY /NOT SATISFACTORY

Approval of the advisory committee

Advisory committee	**Name**	**Signature**
Chairperson		
Members		
1.Intra		
2.Inter		

Professor and Head

ANNEXURE- VIII

ANNAMALAI UNIVERSITY

FACULTY OF AGRICULTURE

DEPARTMENT OF _____

PROFORMA FOR EVALUATION OF THESIS

1. Name of the examiner:
2. Postal Address:
3. Telephone/Mobile:
4. E-Mail:
5. Name of the candidate :
6. Title of the thesis:
7. Date of receipt of the thesis copy:
8. Date of dispatch of the detailed report and thesis by the examiner to the Controller of Examinations:
9. Examiner's recommendations choosing one of the following based on quality of thesis

Please give your specific recommendation (select any one decision from the list below) with your signature and enclose your detailed report in separate sheet(s).

a. I recommend that the thesis entitled ----------

----------submitted by ---------- be accepted for award of the Degree of MASTER OF SCIENCE (AGRICULTURE / HORTICULTURE / AGRI BUSINESS MANAGEMENT) of Annamalai University, Annamalainagar.

(OR)

b. I do not recommend the acceptance of the thesis entitled.

---------- Submitted by ----------
----------for award of the Degree of MASTER OF SCIENCE (AGRICULTURE / HORTICULTURE / AGRI BUSINESS MANAGEMENT) of Annamalai University, Annamalainagar. (Please specify reasons)

Date:

Signature with Office Seal:

Note- Please enclose a detailed report in duplicate duly signed by you giving the merits and demerits of the thesis on the choice of problem, review of literature, methods followed, results and discussion, etc.

PROFORMA FOR REPORT OF THE FINAL VIVA VOCE EXAMINATION

The meeting of the Examining Committee for Mr./Ms. ----------M.Sc.(Ag.) Student Reg.No. ---------- Majoring in ----------was held at ----------a.m /p.m on ----------

The following members were present:

1. ---------- : Chairperson
2. ---------- : Member
3. ---------- : Member
4. _____ : External examiner

The committee took note of the report of the external examiner Dr. ---------- recommending the thesis for acceptance.

The final viva voce examination for the candidate was conducted by the members of the Advisory Committee and external examiner. The candidate has secured satisfactory/unsatisfactory

The Committee recommends/ does not recommend unanimously the award of Degree of M.Sc.(Ag.).to Mr./Ms.----------

1. Chairman
2. Member
3. Member
4. External examiner:

The original report from the External Examiner is attached herewith

Chairperson of the Advisory Committee

Professor and Head

CERTIFICATE FOR HAVING CARRIED OUT THE SUGGESTIONS OF THE EXTERNAL EXAMINER AND ADVISORY COMMITTEE

Certified that Mr./ Ms. ---------- Reg. No. ----------has carried out all the corrections and suggestions as pointed out by the External examiner and the Advisory Committee. He / She has submitted **TWO** copies of his/ M.Sc.(Ag.)./(Hort.)/Agri Business Management thesis in hard bound cover and two soft copies in CD format, two copies each of the abstract of thesis and summary of the findings both in Tamil and English in CD format.

Chairperson

Professor and Head

ANNAMALAI UNIVERSITY

DEPARTMENT OF _____

FACULTY OF AGRICULTURE

Date:

CERTIFICATE

This is to certify that the thesis entitled "----------" submitted in partial fulfillment of the requirements for the award of the degree of ---------- to Annamalai University, Annamalainagar is a record of bonafide research work carried out by ----------, under my guidance and supervision and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has been published / not been published in part or full in any scientific or popular journals or magazines.

Chairman

1. Chairman :
2. Member :
3. Member :
4. External examiner :