ANNAMALAI UNIVERSITY

(Accredited with 'A' Grade by NAAC)

FACULTY OF AGRICULTURE

(Accredited by ICAR)

DEPARTMENT OF ENTOMOLOGY

Academic Regulations and Syllabi

DOCTOR OF PHILOSOPHY IN AGRICULTURAL ENTOMOLOGY

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

2019-2020 Onwards

COMMON REGULATIONS TO ALL PH.D. DEGREE PROGRAMMES OF FACULTY OF AGRICULTURE (FULL-TIME / PART-TIME / EXTERNAL)

REGULATIONS (2019-2020)

1. SYSTEM OF EDUCATION

1.1 These rules and regulations shall govern the Ph.D. Programmes leading to the award of Degree of Doctor of Philosophy in the concerned subject in the Faculty of Agriculture, Annamalai University. They shall come into force with effect from the academic year 2019-2020.

1.2 The semester system shall be followed for all the Ph.D. degree programmes.

1.3 The duration of doctoral programmes is as follows:

Programme	Minimum Years	Maximum Years
Full Time	3	5
Part Time / External	4	6

2. DEFINITIONS

2.1 An **"Academic year"** shall consists of two semesters.

2.2 **"Semester"** means an academic term consisting of 105 instructional days excluding final theory examinations.

2.3 **"Course"** means a unit of instruction to be covered in a semester having specific No., title and credits.

2.4 **"Credit hour"** means, one hour lecture plus two hours of library or home work or two and half hours of library/field practicals per week in a semester.

2.5 "**Credit load"** of a student during a semester is the total number of credits registered by that student during that particular semester.

2.6 "**Grade Point"** of a course means the value obtained by dividing the percentage of marks earned in a course by 10 and the Grade Point is expressed on a 10 point scale and rounded off to two decimal places.

2.7 "**Credit Point"** means the grade point multiplied by corresponding credit hours.

2.8 "**Grade Point Average(GPA)"** means the quotient of the total credit points obtained by a student in various courses 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 scale and the GPA has to be corrected to two decimals.

2.9 **"Overall Grade Point Average (OGPA)"** means the quotient of cumulative credit points obtained by a student in all the courses 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.

3. PROGRAMMES OFFERED

Various Ph.D. programmes offered in the Faculty of Agriculture are as follows: Agricultural Economics, Agribusiness Management, Agricultural Entomology, Agricultural Extension, Agricultural Microbiology, Agronomy, Genetics and Plant Breeding, Agricultural Biotechnology, Seed Science and Technology, Horticulture, Plant Pathology, Soil Science and Agricultural Chemistry and Animal Husbandry

4. ELIGIBILITY FOR ADMISSION

Candidates seeking admission to Ph.D. programme should satisfy the following requirements.

4.1 Candidates with two year master's degree programmes from Universities recognized by Annamalai University are eligible to apply for Ph.D. programmes of the university (Table 1).

4.2 Candidates who have undergone the programme under conventional system should possess not less than a second class Master's degree. The candidates under trimester system should possess a minimum OGPA of 3.00 out of 4.00. For those under semester system 7.00 out of 10.00 is required for various Doctoral programmes. However, this will not apply to SC/ ST candidates, nominees of State Government / Annamalai University / ICAR / and Government of India for whom a pass in the concerned degree is sufficient.

Table – 1: Eligibility Criteria

Doctoral Degree Programmes	Eligibility
1. Agribusiness Management	MBA in Agribusiness
2. Agricultural Economics	M.Sc.(Ag.) in Agricultural Economics/ Agriculture Marketing Management.
3. Agricultural Entomology	M.Sc. (Ag.) Agricultural Entomology
4. Agricultural Extension	M.Sc.(Ag.) in Agricultural Extension
5. Agricultural Microbiology	M.Sc.(Ag.) in Agricultural Microbiology
6. Agricultural Biotechnology	M.Sc.(Ag.) in Genetics and Plant Breeding / Agricultural Biotechnology
7. Agronomy	M.Sc.(Ag.) in Agronomy
8. Genetics and Plant Breeding	M.Sc.(Ag.) in Genetics and Plant Breeding
9. Horticulture	M.Sc.(Ag.) Hort. / M.Sc. (Hort.) /M.Sc. (Hort.) in Fruit Science / Vegetable Science/Floriculture and Landscape Gardening or Architecture / Plantation, Spices, Medicinal and Aromatic Crops
10. Plant Pathology	M.Sc.(Ag.) in Plant Pathology
11. Seed Science and Technology	M.Sc. (Ag.) in Seed Science & Technology
12. Soil Science and Agricultural Chemistry	M.Sc.(Ag.)in Soil Science and Agricultural Chemistry
13. Animal Husbandry	M.V.Sc.in any branch

4.3 Full Time Programme: All full time research scholars shall undergo course work for two semesters as prescribed by the Department. Duration of the programme will be for three years.

4.4 Part Time Programme: The part time programme will be offered to the in-service candidates / Research Scholars of projects of Annamalai University. The candidates of this University should route their application through HOD and Dean, Faculty of Agriculture. The duration of the programme will be of 4 years. The in-service candidates / Research Scholars of projects of Annamalai University will be permitted to register the Ph.D. programme by course work and they have to undergo one year course work by utilizing any eligible leave for that period.

4.5. External Registration: The duration of the programme will be of 4 years. The following are the additional conditions for registration for a Ph.D. programme under external category.

4.5.1 The candidates must register under a research supervisor who is a member of the Teaching Faculty of this University

4.5.2 The candidate should be working as Asst. Professor/Associate Professor/Professor or in equivalent positions on permanent basis in a recognized college where facilities for carrying out research work are available and have post graduate departments for Agrl. subjects or working as research assistants in private or government institutions having research and development facilities and who fulfill the eligibility conditions.

4.5.3 The candidate should have a recognized co-supervisor in parent department of the organization. The co- supervisor may be from other colleges / organization located from the same place if such persons are not available in the parental organizations.

4.5.4 The candidate shall undergo the course of the required credits during I year of the programme in Annamalai University Campus. He / She shall carryout the research at his / her parental organization for the entire of period of the programme.

4.5.5 NOC (No Objection Certificate) is to be produced from the employer of the institution / Organization where he / she is working and attached along with the application ii. Co-supervisor acceptance letter should be also be enclosed with the application form.

5. SELECTION PROCEDURE

A candidate who wishes to undertake Ph.D. programme of this University either full time or part time or external registration should apply in the prescribed form on or before the due date.

Applications which fulfill the above conditions (mentioned in the Prospectus) will be scrutinized by a Departmental Research Committee consisting of the Head of the Department (Coordinator), two Professors, one senior Associate Professor and

one senior Assistant Professor (not more than five). Eligible candidates will have to appear for entrance test and interview on the dates specified by the University. The selection of the candidates shall be based on marks obtained in the qualifying degree, a written test and an interview.

The weightage for Qualifying Degree Examination will be given for 50 marks. The written test shall comprise objective type questions and examine research aptitude, grasp of the subject, intellectual ability and general knowledge of the prospective candidates. The question paper for the written test shall be prepared for one hour duration. Question papers will be set and evaluated by the DRC for 25 marks.

The interview will be conducted for 25 marks. The cut off marks for the selection shall be fixed as 50 percent. NET qualified candidates are exempted from the entrance test, but they have to appear for the interview. The minutes of the DRC together with the recommendation will be placed before the Vice-Chancellor who in consultation with the Dean of the Faculty and Head of the Department will select and admit the applicant to work under the guide proposed.

6. CREDIT GRADE POINT REQUIREMENTS

6.1. A student enrolled for Doctoral program to become eligible for the degree is required to complete 75 credits inclusive of 45 credits of research as detailed below

S.No.	Details	Credit Hours
1.	Major-Courses	15
2.	Minor-Courses	8
3.	Supporting-Courses	5
4.	Seminar	2
5.	Research	45
	Total	**75**

6.2. In a semester, a full time Ph.D. student can register a maximum of 15 credits excluding research. However, the research credits registered should not exceed 12 per semester. Semester wise distribution of credits is given in the respective Ph.D. programmes. The total research credits for PT and EXT candidates should be distributed in all the eight semesters. The Ph.D. students (FT/PT/EXT) should complete their course work within two semesters in the first year in Annamalai University campus.

6.3. Requirements for Ph.D. programme shall also include successful completion of thesis research in the major field of study and submission of thesis thereon.

7. ATTENDANCE REQUIREMENT

7.1. "One hundred percent attendance is expected from each scholar. A student who fails to secure 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 shall be awarded 'E' (incomplete) and will be required to repeat the subject when ever offered.

7.2. In respect of the student who has absented himself / herself for classes with or without valid reasons, that period will be treated as absence only and not as leave. Also, no attendance will be given for writing make up tests.

7.3 In case of new admission, for calculating 80 percent attendance in the first semester, the number of working days will be calculated from the date of joining of the students who are permitted to join late due to administrative reasons. However, for genuine reasons, condonation of attendance deficiency may be considered by the Vice - chancellor on the recommendation of the Advisory committee, HOD and Dean, Faculty of Agriculture on payment of condonation fee prescribed by the university.

7.4 Students absenting from the classes with prior permission of the HOD on official University business shall be given due consideration in computing attendance.

7.5. In respect of students who had absented for the mid-semester examination on University business with prior permission of the HOD and Dean, Faculty of Agriculture, the makeup mid-semester examination should be conducted ordinarily within 15 working days from the date of conduct of the mid-semester examination.

7.6. The students who absent himself/herself for mid-semester examination in a subject on genuine reasons shall be permitted on the recommendation of the course teacher / Research Supervisor and Head of the Department concerned. Missing examination should be completed within 15 working days from the date of respective examination on payment of missing examination fee prescribed by the university.

7.7 An employee of the University admitted to the programme leading to the Ph.D. Degree as a part-time internal candidate in accordance with these ordinances shall be required to work for a minimum period of 30 days per annum during the period of research. They shall carry out research work without affecting their regular duty.

7.8 External scholars are required to mark attendance maintained by the research supervisor/co-supervisor for a minimum compulsory period of 30 days per annum during their period of research.

7.9 External scholars are required to visit Annamalai University campus at the end of every year on a specified date to appear before the Research Advisory Committee (RAC) for review of the progress of their research work.

7.10 The attendance certificate signed by the research supervisor/co-Supervisor shall be sent to the Director, CARE through the respective Head of the Department and the Dean at the time of submission of the Synopsis.

8. RESEARCH ADVISORY COMMITTEE (RAC)

8.1. Each Ph.D. scholar shall have an RAC to guide the student in carrying out his/her programme. A Research Advisory Committee shall be constituted with the approval of the University for each candidate (full-time, part-time and external) separately, immediately after his/her admission. The purpose of the RAC is to provide expert opinion on frontline research. The Research Advisory Committee shall consist of the Head of the Department or a Professor

nominated by the Vice-Chancellor as the Chairperson, the Research Supervisor as the Convener, and two members who are experts in the field nominated by the Vice-Chancellor (one member from the same Department, and the other member from another related Department of our University/another University in Tamil Nadu/other states. The research supervisor in consultation with the HOD will propose the other three members.

8.1.1 Research Supervisor: Every student shall have a research supervisor (among the recognized guides), who will be appointed by the Vice-Chancellor on the recommendation of the Head of the Department and the Dean, Faculty of Agriculture. Research supervisors approved by the Vice-Chancellor only can be the guide for the students.A teacher having Ph.D with 5 years service and PG teaching is eligible for teaching and guiding Ph.D programme. A teacher should have a minimum of three years of service before retirement for allotment of doctoral candidates. The research supervisors who wish to avail leave/lien/deputation beyond a period of six months shall propose a Co-supervisor in the concerned subject for the candidates registered with them and it may be intimated to the University well in advance. The final approval of the proposal rests with the Vice-Chancellor. For external candidate, a Co-supervisor from his/her parental organization will be the Co-Chairman of the Advisory Committee.

8.1.2 Functions of the RAC: The Research Advisory Committee shall have the following functions:

1. Discuss, advice and recommend on all matters connected with the candidate's research from admission till the submission of the thesis.
2. Approve the topic of research and the synopsis.
3. Assess and approve the progress reports of Ph.D. students in the prescribed format and to report to the University on the fitness or otherwise of the candidate to proceed with his/her research work for the Ph.D.
4. If necessary, recommend and approve change of title of dissertation/Thesis, change of research supervisor and status of Researcher (full time to part time and vice-versa)
5. Conduct and supervise the presentation by the candidate of the final draft of his/her proposed thesis for approval before the submission of synopsis of the thesis to the University and to give a certificate to this effect to be submitted along with the synopsis.

8.1.3 The Research Advisory Committee will meet once in six months:

- to scrutinize the research proposal / progress report submitted by the candidate
- to assess the conduct of experiments/field work, peruse laboratory notebooks, data recording, analysis, and publication
- to review and endorse the annual progress report of the candidate.
- to approve the synopsis of the thesis.
- The convener will convene the Research Advisory Committee meetings with intimation to the Director, CARE

8.2. Changes in RAC

The proposals for changes in the RAC is to be sent to the Director, CARE, through HOD and Dean for approval, if it is keenly felt that such changes are absolutely necessary.

8.3. Change of Research Supervisor

8.3.1 Change of research supervisor shall not be permitted as a routine. In exceptional cases, such change may be permitted, if valid reasons are provided by the candidates. The Committee headed by the Vice-Chancellor shall look into the request of the petitioner, if there is any conflict between the scholar and the research supervisor. The research supervisor under whom the scholar has originally registered shall give a "No Objection Certificate" and the new proposed Research Supervisor should give a "Certificate of Willingness" to guide the candidate. The final decision will rest with the University. However, the Vice-Chancellor, on the recommendation of the RAC and Dean's Committee, has the right to assign a new research supervisor to the research scholar.

8.3.2 When the change of Research Supervisor is approved, the candidate shall work for a minimum of one year with the new Research Supervisor if the topic of his/her research is different under the new supervisor, provided he/she fulfils the attendance requirements.

8.4 Change of Topic of Research

8.4.1 Change of the specific area of research may be permitted within one year from the date of admission and request must be submitted with the recommendations of the RAC. In such cases, the minutes of the RAC meeting must include whether the course work undertaken by the candidate is relevant to the new research area and the competence of the research supervisor in this field.

8.4.2 If the RAC is of the view that there is a major change in the specific area of research and is not relevant to the course work undertaken, the candidates will have to go through the process of fresh examination pertaining to the area of research.

8.5. Absence of member during qualifying/final Viva-Voce examination

Under extra-ordinary circumstances if the qualifying/ final viva-voce examination to Ph.D. student has to be conducted in the absence of one or two RAC members, permission to conduct the examination by co-opting another member in such contingencies should be obtained from the Director, CARE in advance.

9. EVALUATION OF STUDENT'S PERFORMANCE

All students shall abide by the rules for evaluating the course work under the semester system of education, as prescribed from time to time by the university.

9.1. Examinations

There will be two examinations viz. mid semester and final examination. Wherever the course has practical, there will be a final practical examination also.

9.2. Grading

- The duration of mid semester examinationwill be of one hour and final examinations in theory and practical will be conducted for three hours each.
- The mid semester examinations will be conducted by course teachers during the ninth week of the semester as per the scheme drawn by HOD, evaluate and send the marks obtained by the students to the Director, CARE through HOD within seven working days.
- There will be final examination separately for theory and practical which will be conducted by the University. Each final theory and practical examinations will be evaluated by two examiners (one will be the course teacher and another will be the senior faculty of the Department).
- The distribution of marks will be as indicated below:

S.No	Examination	Course with practical	Course without practical	Course without theory
1	Mid-semester	30	30	30
2	Final theory	40	70	-
3	Final practical	30	-	70
	Total	**100**	**100**	**100**

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

Mid semester:

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	5 out of 7	(5 x 2)	10 marks
4	Essay type	2 out of 3	(2x5)	10 marks

Final Theory:

Courses without practicals (70 marks)

1.	Short notes	5 out of 7	(5 x 4)	20 marks
2	Essay type	5 out of 7	(5 x 10)	50 marks

Courses with practicals (40 marks)

1.	Short notes	5 out of 7	(5 x2)	10 marks
2	Essay type	5 out of 7	(5 x 6)	30 marks

9.3. Minimum Marks for Pass

a) The student should secure a minimum of 60 per cent marks separately in the theory and practical and an aggregate of 70 per cent to secure pass in the subject.

b) Each subject shall carry a maximum of 100 marks for purpose of grading. The grading will be done as grade point. i.e., the percentage of marks earned in a subject is divided by 10. The grade point is expressed on a 10 point scale up to two decimals.

c) Students who secure marks below 70 per cent in a subject will be awarded 'F' grade and students without having the required minimum attendance of 80 per cent will not be allowed to write the final examination and they will be awarded 'E' grade. Students who secure 'F' grade should appear for re-examination in the subsequent semester.

d) If a student secured 'E' grade, he/she has to re-register and attend the course again during the next academic year.

9.4. Minimum GPA Requirement

a) A Ph.D. student to continue his/her studies in the University, should maintain certain minimum Average Grade Point prescribed here under
b) Earn a Grade Point of 7.00 for a pass in each subject.

For purpose of continuing as a student in the university, a candidate is required to earn an Overall Grade Point Average of not less than 7.50 at the end of each semester

c) A Ph.D. student may repeat the course(s) in which he/she gets a Grade point below 7.50 and above 7.0 to improve the OGPA.

9.5. Re-Examination

Re-examination is permitted only for the final theory and practical examinations. The students who secure 'F' grade are permitted to write the re-examinations as and when conducted with the permission of university. The re-examination fee as prescribed by university per course is to be paid on or before the prescribed date.

A student is permitted to write the final theory and practical examinations only two times during the course period of three years excluding the regular final examination. In the event of a student who fails to secure a pass in the two re-examinations permitted, he/she has to re-register for the course along with juniors.

The marks secured in mid semester examination will be retained and the student should produce the practical record during re-examination. The registration for the re-examination shall be done after mid-semester examination on the date specified by the Director, CARE. Each registration is considered as an attempt even if the student absents for the examination.

9.6. Return of Valued Answer Papers

The valued answer papers of mid-semester shall be shown to the students after the examination. Discrepancies if any, in awarding marks, the student can approach the teacher concerned immediately for rectification. The answer paper should be retained with the course teacher for six months and then

disposed off. Evaluated final theory papers have to be retained up to six months by the Director, CARE after the conduct of examination and then disposed off.

10. CREDIT SEMINAR

Seminar is compulsory for all students and each student should register and present two seminars each with 0+1 credits. A student can register only one seminar in a semester and only after successful completion of the first seminar the student is permitted to register for the second seminar.

10.1. Credit Seminar Topic

10.1.1 The seminar topic should be only from the major field and **should not be related to the area of thesis research.**

10.1.2 The seminar topics are to be assigned to the students by the research supervisor in consultation with HOD within three weeks after commencement of the semester.

10.1.3. Under the guidance and supervision of the research supervisor of the RAC,the student should prepare a seminar paper containing not less than 50 typed and printed pages with a minimum number of 75 references covering the recent 10 years time after reviewing all the available literature and present the seminar after completion of 80% attendance in the semester in the presence of the HOD, RAC, staff and post-graduate students of the concerned department.

10.1.4. The circular on the presentation of the seminars may be sent to other Departments to enable those interested to attend the same.

10.1.5. The research supervisor will monitor the progress of the preparation of the seminar and correct the manuscript. The student will submit 2 copies of the corrected manuscript to the HOD through chairman before presentation. The student will incorporate the suggestions and carry out corrections made during the presentation and resubmit three fair copies to the HOD (one to Dept. library, the second to the research supervisor and the third for student) within 15 days after presentation.

10.1.6. The performance of the student in the credit seminar will be evaluated and grade point awarded by the HOD along with the RAC for 100 marks. Grade Point may be given based on the following norms:

Details	Marks
Coverage of literature	40
Presentation	30
Use of audio visual aids	10
Capacity to participate in discussion and answer the questions	20
Total	**100**

11. QUALIFYING EXAMINATION

Only those students who successfully complete the qualifying examination will be admitted to candidacy of the degree. The qualifying examination consists of written and oral examination.

11.1. Minimum requirement for Qualifying Examination

The students who have completed all the courses and earned a grade point average of not less than 7.5 will be permitted to appear for the qualifying examination. Students who do not satisfy these requirements shall not be permitted to take up the qualifying examination. The qualifying examination will be conducted after the completion of course work.

11.2. Selection of Examiner

A **panel of five external examiners** for qualifying examinations shall be given by the RAC in consultation with HOD before three months of the date of completion of the student's course work to the Director, CARE. One of them will be appointed as external examiner.

11.3. Written Examination

The written examination consists of two papers covering major and minor subjects only.The Director, CARE will conduct the examination by obtaining the question paper from Head of Department to be prepared in consultation with the course teachers concerned.

The question paper for the written examination will be of 3 hours duration and each question (Essay type) need not be restricted to any particular topic in a course but it should be a comprehensive covering of each unit of the syllabus of each course. The written examinations will be conducted at the same time in all disciplines. The answer papers will be evaluated by the research supervisor and Head of the Department or a senior faculty nominated by the Head of the Department. Qualifying marks for passing the examination will be 60. The viva-voce will be conducted by the external examiner after the candidates passes the qualify examination.

11.4. Qualifying viva-voce Examination

The RAC shall conduct the qualifying viva-voce examination with one external member who shall be a specialist in the subject from outside the university

11.5. The Heads of Departments will monitor and coordinate the conduct of the qualifying viva.The performance of the candidate will be graded as Satisfactory / Unsatisfactory.

11.6. Communication of Results of Qualifying Examination

The research supervisor shall act as chairman for the examination committee and shall be responsible for communicating the results of the examination to the Controller of Examination through HOD in the prescribed format.

11.7. Failure/Absence in Qualifying Examination

When a student fails or absents for the qualifying examination, he/she may apply again for permission to appear for re-examination to the Controller of Examination with the recommendation of the chairman of the RAC and Head of the Department. A student, who applies for re-examination should attend written examination and viva-voce. Re-examination shall not take place earlier than three months after the first examination and it will be conducted by the advisory committee as previously indicated. If a student fails in the re-examination, further re-examination will be considered on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

If the students fail in the qualifying examination, he / she is not permitted to register for further research credits.

12. THESIS RESEARCH

12.1. Selection of Topic

The thesis research for the Ph.D. degree should be of the nature of a definite contribution to the subject and the results should be of sufficient importance to merit publication. The findings should have some practical utility or should lead to theoretical contribution. The thesis shall be on a topic falling within the field of the major specialization and shall be the result of the student's own work. A certificate to this effect duly endorsed by the major advisor shall accompany the thesis.

12.2. Research Proposal

The research scholars shall present their broad area of research and submit a proposal to the Research Advisory Committee at the end of the first semester. The research proposal has to be presented by the student in a meeting organized by the Head of the department to get the opinion / suggestion of the scientists of the department for improving it. Three copies of the research proposal in the prescribed format should be sent to the Director (CARE) through the Head of the Department for approval

The distribution of research credit will be as follows

Semester	Credit Hours
I Semester	0+1
II Semester	0+2
III Semester	0+12
IV Semester	0+12
V Semester	0+9
VI Semester	0+9
Total	**0+45**

The total research credits for PT and EXT candidates should be distributed in all the eight semesters as advised by RAC.

12.3 Evaluation of Thesis Research

After assigning the research problem, for each semester, the student has 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 has to be given to the student for carrying out the work during the semester.

12.3.1 Attendance register must be maintained in the Department by HOD for all the students to monitor whether the student has 80% of attendance in research.

12.3.2 The student has to submit his/her research observation note book to the research supervisor whowill 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.

12.3.3 After completion of 80% attendance for research and on or before the last day of the semester, the research Scholars, both full time and part time, shall submit Progress Reports in the prescribed format (Annexure-3) duly endorsed by the Research Advisory Committee to the Director, CARE until they submit their synopsis.

12.3.4 Failure to submit the progress reports shall entail automatic cancellation of registration.

12.3.5 The minutes of the meeting of the Research Advisory Committee along with enclosures will be sent to the Director, CARE.

12.3.6 The review meetings of the RAC may also be conducted through video conferencing or internet chat if the candidate or the Research Supervisor is in a foreign country.

12.3.7 Candidates who are recipients of fellowships such as JRF/SRF directly from any of the funding agencies/ shall send the progress reports and the utilization certificates in the format prescribed by the respective funding agency through proper channel.

12.3.8 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 programme and awarded **SATISFACTORY** by the RAC. Under the said situation the student can be permitted to register for fresh research credits in the subsequent semester. If the student is awarded **UNSATISFACTORY**, he/she has to re-register the same block of research credits in the subsequent semester.

SITUATION – II

The student who has not secured the minimum attendance of 80 percent shall be awarded **grade E**. The student has to re-register the same block of research credits for which 'E' grade was awarded earlier in the following semester with prior permission. Until the completion of reregistered credits, the student should not be allowed to register for fresh (first time) research credits.

SITUATION – III

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

a) Failure of crop
b) Non-incidence of pests or disease or lack of such necessary experimental conditions.
c) Non-availability of treatment materials like planting materials chemicals, etc.
d) Any other impeding / unfavourable situation for satisfying the advisory committee.

Under the said situations grade **EE** should be awarded.

In the mark list, it should be mentioned that **E** grade or **EE** grade was awarded due to 'lack of attendance' or 'want for favourable experimental conditions'.

SITUATION – IV

When the student failed to complete the work even in the 'second time' registration, the student will be awarded **UNSATISFACTORY** and in the mark list the 'second time' should be mentioned.

For the registration of research credits for the third time, permission has to be obtained from the Dean based on the recommendation of the RAC, and HOD. Permission for registration for the fourth time shall be given only by University based on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

13. SUBMISSION OF THESIS

The research credits registered in the last semester should be evaluated only at the time of the submission of thesis, by the RAC. Students can submit the thesis at the end of the final semester. If a student has completed the thesis before the closure of the final semester, the research supervisor can convene the RAC meeting and take decision on the submission of the thesis, provided the student satisfies 80 per cent attendance requirement. The candidate shall be allowed to submit his/her thesis after the completion of stipulated period. A grace period of 30 days may be allowed to submit the thesis after the prescribed duration. If the thesis is not submitted even after the grace period, the student shall pay the tuition fee for the year.

If a student is not able to submit the thesis within the grace period, the student has to re-register for the credits in the forthcoming semester. The student who re-registers the credits after availing of the grace period will not be permitted to avail of grace period for the second time. The Head of the Departments can sanction the grace period based on the recommendation of advisory committee and a copy of the permission letter along with the receipt for payment of fine should accompany the thesis while submission

Five copies of the thesis (in the approved format) shall be submitted together with the submission fee not later than three months after the submission of the synopsis. No dues certificates from the Department and Central Libraries, Hostel, Stores, etc. must be submitted with the thesis copies. The Research Supervisor shall forward the thesis copies with the enclosures to the Director, CARE through the HOD and the Dean. A soft copy of the thesis in PDF fromat as prescribed by Shodhganga, shall also be submitted.

The Ph.D scholars have to publish a minimum of two research papers in Scopus / Web of Science indexed journal. The synopsis will be accepted for processing only after showing evidences for publications of 2 such articles.

The soft copy of the thesis shall be checked for plagiarism using Turnitin software. Beyond the percentage of reproduction prescribed by UGC will not be accepted for evaluation.

13.1 Pre-submission Presentation

1. The pre-submission presentation of the thesis is a requirement to enrich the scholar and to fine tune his/her research presentation

2. This presentation shall be conducted before the submission of the synopsis in the presence of the RAC, Supervisor/Co-Supervisor, Faculty members, Research Scholars, M.Phil., and /or P.G. Students.
3. The scholar is expected to present the first draft of the research work or explain the findings/problems faced.
4. The gathering may suggest ideas/references to be consulted/suggestions to improve the work and so on.
5. A report on this event along with an attendance sheet shall be forwarded by the Research Supervisor with the endorsement of the RAC and HOD to the Director, CARE.

13.2 Submission of Synopsis

1. The submission of synopsis may be permitted 3 months before the completion of required duration on successful completion of course work
2. The Research Scholar shall submit 3 copies of the synopsis approved by the Research Advisory Committee along with a soft copy to the Director, CARE through the Research Supervisor, the HOD and Dean of the respective Faculty. Guidelines for the preparation of the synopsis are appended in Annexure -4
3. Name of the candidate and name of the supervisor shall not be mentioned anywhere in the synopsis; enrolment number of the candidate alone shall be given. A model cover page for a synopsis is given in Annexure – 5

13.3 Guidelines for Preparation of Thesis

1. The thesis shall not exceed 250 pages excluding the Bibliography, Appendices, etc. If it exceeds the specified number of pages, the Research Supervisor should write to University with the reasons and get prior approval from the University. The candidate shall pay a penalty for the excess number of pages as decided by the Deans Committee. The thesis should be in A4 size. The specification for the preparation of the thesis are given in Annexure-7. A model cover page for a thesis is given in Annexure -8.

2. The thesis shall be typed on both sides of the page in order to save paper and postage

3. The thesis shall contain a Certificate from the guide (Annexure-9) 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 guide indicating the extent to which the thesis represents independent work on the part of the candidate should also be made.

4. The thesis shall also contain a Declaration by the candidate (Annexure -10) 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 duly acknowledged and no part of the thesis is plagiarized.

14. VALUATION OF THE THESIS

Panel of Examiners

The thesis submitted in partial fulfillment of the Ph.D. degree shall be evaluated by two external experts one from within the country and the other from outside the country appointed by the Vice-Chancellor on the recommendation of the research supervisor of the RAC, HOD and Dean. They shall be chosen from a panel of at least five names of specialists separately from within the country and outside the country in the particular field, suggested by the research supervisor **(Acceptance letters from the examiners must be attached)**. The external experts shall send their evaluation reports of the thesis directly to the Director, CARE along with the copy of the evaluated thesis. The Director, CARE on receipt of the reports from the two examiners will send them to the concerned guide who is the convener of viva-voce board. The guide will send the consolidated report with his remarks to the Director, CARE through the Head of the Department. On the satisfactory reports of the evaluation, viva-voce examination will be arranged.

After a student's thesis for Ph.D. degree is evaluated as indicated above, the thesis shall be finally accepted for the award only after the student satisfactorily completes a final viva-voce examination. The Viva-Voce board comprises the student's RAC with the addition of the external examiner who valued the thesis, and the HOD. If the HOD happens to be the research supervisor, the Dean, Faculty of Agriculture will nominate a senior member of the staff of the concerned Department as a member. In case of external candidates, the co-supervisor will also serve as a member of the viva-voce board. The candidate is expected to defend the thesis at the viva-voce examination.

The degree shall be awarded on the unanimous recommendation of the examining committeeas **satisfactory** with regard to the thesis and the performance of the student in the final oral examination. The recommendation of the committee shall be forwarded to the Director, CARE by the research supervisor through HOD and Dean which shall be signed by all members of the committee and the external examiner. A candidate who is not successful (unsatisfactory) at the viva –voce examination will be permitted to undergo the viva voce examination again within a period of three months.

14.2. Revision and Resubmission of Thesis

i. If an examiner recommends change / further work, the thesis will be referred to the same examiner after compliance for his opinion. In case of rejection by any one of the examiners, the thesis will be sent to another examiner and his / her recommendation will be final.

ii. If the thesis is recommended to be revised by one or both examiners, the points of revision will be indicated clearly in the report. The necessary correction should be carried out, and the revised version should be sent to the

concerned examiner(s). If the examiner(s) is / are still not satisfied with the revised version, the thesis will be rejected. If the thesis is accepted by the examiners (Evaluation), Viva–Voce examination will be conducted by the viva-voce board.

14.3. Re-registration and Submission of Thesis

The minimum of 80% 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 of 3 or 4 years.

14.4. Extension of Time

1. Research scholars who do not submit the thesis within the stipulated period as per full-time/part-time/external mode should apply for extension of time three months before the completion of 3 or 4 years. Extension of time and the fees to be paid will be considered by the Deans Committee, if the extension is duly recommended by the RAC, Head of the Department, and the Dean of the Faculty, such candidates will be eligible for extension of time for a maximum period of two years.
2. The scholar will have to enroll as fresh candidates if he/she fails to submit the thesis within the maximum extension period of three years when granted.
3. If a scholar requires a few more months after the expiry of the maximum extension period of two years for the submission of the thesis as per the evaluation of the RAC, duly recommended by the Head of the Department and the Dean of the Faculty, as an exceptional case, the Deans committee may consider for re-registration to enable the scholar to submit the thesis. In any case, the time granted shall not exceed six/ twelve months.

14.5. Number of Chances

A candidate will not be permitted to submit a thesis for the degree on more than two occasions. However, it will be open to the syndicate, if the Board of Examiners so recommend, to permit the candidate to submit a thesis on a third occasion. Also, he/she will not be permitted to appear for the viva-voce examination on more than two occasions.

15. DISCONTINUANCE AND READMISSION

15.1. Students admitted to the PhD degree who discontinues their studies before completing the degree with written permission from the University may be re-admitted to the degree programme, provided that the student should have completed the course work before such discontinuance. However the period of such discontinuance should not exceed five years for Ph.D. Degree from date of admission.

15.2. After completion of course work and qualifying examination, a student is eligible to discontinue temporarily his research program only once within 5 years for PhD program. If the discontinuation period exceeds two semesters, the student has to forego the research credits already registered and register afresh with revised program. In the case of field experiments or laboratory experiments in which continuity is essential for research and if a student

temporarily discontinues in the middle without completing the experiments, then the entire experiment should be repeated even if the discontinuation period does not exceed two semesters.

15.3. A student joining the studies, after discontinuation should pay the fees of the existing semester.

16. PUBLICATION OF THE THESIS

The thesis, whether approved or not, should not be published in full or abridged form without the permission of the Syndicate, which may grant permission for the publication under such conditions as it may impose.

17. Each Department should maintain a list of theses produced so far with the abstract of the same.

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PROGRAMME OUTCOMES
GENT 81 – Ph.D. Agricultural Entomology
All Ph.D. Entomology doctorates will: **PO 1:** have basic and advanced domain expertise in Entomology **PO 2:** develop wholesome and in-depth knowledge in areas of specializations in Entomology. **PO 3:** have command over handling of advanced instrumentation for carrying out cutting edge research **PO 4:** have expertise in carrying out independent research, writing and presenting technical documents

PO and Co Mapping Matrix

Correlation levels 1, 2 and 3 are as defined below:

1 -Low
2- Moderate/ Medium
3 - Substantial /High

Ph.D. in Entomology (Revised Syllabus 2019-2020 onwards)

Semester wise Distribution of subjects

Subject code	Subject Title	Credit hour (Theory + Practical)
Semester - I		
Major Courses *	***Three out of four major courses**	
ENT 811	Techniques in Entomological Research	1+2
ENT 812	Insect ecology and Ethology	2+1
ENT 813	Advances in storage and quarantine Entomology	2+1
ENT 814	Insect systematics and immature insects	1+2
Minor Course#		
XXXXXX	Minor course from other discipline	2+1
Supporting Courses		
COM 811	Advances in computing applications	0+1
LIS 812	Advances in Agricultural information Retrieval	0+1
ENT 801	Research	0+1
ENT 081	Seminar	0+1
	Total	**16 Credits**
Semester - II		
Major Courses **	****Two out of four major courses**	
ENT 821	Emerging trends in plant resistance to pests	2+1
ENT 822	Advances in toxicology of insecticides and bio-rationals	2+1
ENT 823	Advances in bio suppression of insect pests	2+1
ENT 824	Advances in non- insect pests management	2+1
Minor Courses		
XXXXXX#	Minor course from other discipline	2+1
ENT 826	MOOC	2+0
Supporting Courses		
STA 821	Advances in design of experiments	2+1
ENT 802	Research	0+2
AEN 082	Seminar	0+1
	Total	**17 Credits**
Semester - III		
ENT 803	Research	0+12
Semester - IV		
ENT 804	Research	0+12
Semester - V		
ENT 805	Research	0+9
Semester - VI		
ENT 806	Research	0+9
	Grand Total	**75 Credits**

#All minor courses should be from other Departments

ENT 811 -TECHNIQUES IN ENTOMOLOGICAL RESEARCH (1+2)

LEARNING OBJECTIVES

To expose the learners to essential entomological techniques
To give hands on training in techniques.
To educate the guidelines in laboratory and field researches.

THEORY

Unit I: Entomotaxy

Insect collection, preservation,preparation of insects for scientific study,temporary and permanent mounts.

Unit II: Measurement and documentation

Micrometry, haemocytometry, growth assessment, life table, ETL, EIL, LC_{50}, microphotography.

Unit III: Rearing of test insects and bioassays

Laboratory rearing of insects – natural diet - artificial diet, rearing of insects under semi-field conditions, sampling techniques - data recording, Bioassay - behavioural assays - dose response assays - enzyme assays, determination of antifeedant, repellent and fumigant effects.

Unit IV: Laboratory and Field experiments

Equipment for entomological research – olfactometer – Soxhlet apparatus-microtome -atomic absorption spectrophotometer- gas chromatography - high performance liquid chromatography-spectrophotometer – centrifuge - potter's tower – growth chamber – vacuum evaporator –micro applicator, fixing of treatments - basic statistical designs - appropriate replication -data recording – analysis- software.

UnitV: Molecular Techniques in entomology research

DNA isolation – electrophoresis – sequencing, protein isolation- SDS-restriction endonuclease analysis - southern and western blots - vector phages - genetic markers- DNA barcoding- Insect DNA amplification - PCR methods,DNA synthesis, RAPD - RFLP in insect identification.

PRACTICAL

Collection of insects from various environment and preservation, Measurement of the appendages, cell concentration, food use efficiency, life table and LC_{50}, microphotography, Rearing of test insects in laboratory and semi-field conditions, Sampling methods and data recording, bioassays, essential equipment in entomological research, DNA isolation, protein estimation, barcoding.

THEORY LECTURE SCHEDULE

1. Techniques, tools and chemicals used in insect collection and preservation
2. Procedure for temporary and permanent mount of insects and their appendages
3. Principles of micrometry and calibration, haemocytometry
4. Theories and laws of insect growth
5. Life table studies – concepts and uses
6. Concepts of ETL, EIL and LC_{50}calculations
7. Principles of microphotography
8. **Mid semester examination**
9. Requirements for rearing of insects in laboratory/field, Benefits and composition of artificial diet
10. Methods of sampling and data recording
11. Basic principles and requirements of bioassay
12. Working principles of important equipmentused in entomological research
13. Statistical designs, software
14. Molecular techniques- principles and procedures
15. Selection of markers and PCR methods
16. DNA barcoding
17. RAPD - RFLP in insect identification

PRACTICAL SCHEDULE

1. Practising insect collection from aquatic and subterranean environment
2. Practising insect collection from various crop ecosystems
3. Practising insect collection from animals and birds
4. Practising wet preservation
5. Preparation of permanent slides
6. Measurements on antennal segments, leg segments and setae
7. Head capsule measurement to recognize the larval instars
8. Measurements on blood cells and NPV concentration
9. Preparation of life table for a lepidopteran insect
10. Working of nutritional indices for a lepidopteran insect
11. Calculating LC_{50} values
12. Practicing microphotography
13. Laboratory rearing of Lepidopteran insect – leaf feeder and borer
14. Laboratory rearing of Coleopteran and Dipteran insects
15. Rearing of aphids, mealybug, brown plant hopper
16. Preparation of artificial diet
17. Practising various sampling techniques anddata recording
18. Conducting bioassay using insecticides
19. Conducting bioassay to identify food preference–olfactometer
20. Conducting bioassay to assess the repellent and antifeedantbehaviour insect
21. Estimation of acetyl cholinesterase activity, lactate Dehydrogenase (LDH) activity
22. Estimation of Na^{+}- K^{+} ATPase activity, sodium and potassium concentrations

23. Estimation of digestive enzymes
24. Extraction of plant alkaloids in Soxhlet apparatus
25. Practising microtome sectioning
26. Sample analysis using atomic absorption spectrophotometer
27. Sample analysis using Gas Chromatography - High Performance Liquid Chromatography
28. Practising software
29. Electrophoresis techniques
30. Protein isolation
31. Southern and western blots
32. DNA barcoding
33. Insect DNA amplification

Practical Examination

COURSE OUTCOMES

CO 1: Understand insect preservation and permanent slide making
CO 2: Demonstrate various techniques like micrometry, haemocytometry, lethal dose etc.,
CO 3: Practice diet preparation, rearing of insects, bioassay, and sampling techniques
CO 4: Explain working principle of GC, HPLC, Potter's tower, microapplicator etc.,
CO 5: Discuss the molecular techniques like electrophoresis, DNA amplification by PCR, RAPD etc.,

CO – PO MAPPING

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

References

Trigunayat, M.M. 2009. A manual of Practical Entomology (2nd Edition). Scientific Publishers (India), Jodhpur. 351p.

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

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

Kerkut, G. A. and L.I. Gilbert. 1985. *Comprehensive Insect Physiology*, *Biochemistry and Pharmacology*, 13 Volumes, Pergamon Press, Oxford.

Nation, J. L. 2015. *Insect Physiology and Biochemistry*, Third Edition, CRC Press, New York, 644 p.

Lawrence I Gilbert. 2012. Insect Molecular biology and Biochemistry. Elsivier, Academic press, USA. 574 p. https://doi.org/10.1016/C2009-0-62118-8

Douglas B. Murphy. 2001. Fundamentals of Light Microscopy and electron Imaging. Wiley-Liss, Inc. USA. 368p.

Nikalje A.P. and Bhosale, D. 2017. A handbook of Chromatography. Scholar's Press Verlag Omniscriptam, Deutschland, Germany.

Link for Books in various types of Microscopy
https://www.tedpella.com/books_html/booksA.htm

ENT 812 -INSECT ECOLOGY AND ETHOLOGY (2+1)

LEARNING OBJECTIVES

- To impart in-depth knowledge on advanced ecological concepts, modelling and behaviour of insects and their application in IPM
- To understand ecosystem ecology and role of biogeochemical cycles
- To gain knowledge on insect ethology and basic concepts in ethology
- To understand the role of ethology in pest management

THEORY

Unit 1 – Physiological and Behavioural ecology

Scope of Insect ecology in pest management –Ecosystem approach – Physiological and behavioural ecology – Resource acquisition – quality, acceptability and availability. Resource allocation – Resource budgeting, assimilation and efficiency of use - trade-offs. Nutritional Ecology. Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies - timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict.

Unit II Population ecology

Population structure – processes – life history characteristics - Models of Population Change- Exponential and Geometric Models, Logistic Model, Complex Models, Computerized Models – Biogeography – Wallace realms – Island biogeography theory – Spatial dynamics – Models of spatial dynamics – Use of GIS – Raster model and Vector model.

Unit III Ecosystem ecology

Ecosystem structure – energy flow – biogeochemical cycles – climate modification by organisms- Herbivory, pollination, seed predation and dispersal, decomposition – their functional groups, measurement, effects. Biodiversity and Conservation- Ecological Indicators. – Role of insects as ecosystem regulators – NPP regulation by insects – Development of IPM concept.

Unit IV Insect ethology

Behaviour- History of Ethology- development of ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism. Orientation- Forms of primary and secondary orientation including taxes and kinesis.

Unit V Ethology in IPM

Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

PRACTICAL

Assessment of distribution parameters, Assessment of resource size, Construction of Life tables, GIS in modelling, Studies on biodiversity conservation and ecological indicator insects. Studies on pollinators and decomposers, Characterization of Natural eco-systems and agro-ecosystem, Ecology based pest management protocols in various crop ecosystems, sensory adaptation and habituation,chemical and odour cues in host selection.

THEORY LECTURE SCHEDULE

1. Scope of Insect ecology in pest management and Ecosystem approach
2. Physiological and behavioural ecology – Resource acquisition – quality, acceptability and availability.
3. Resource allocation – Resource budgeting, assimilation and efficiency of use - trade-offs.
4. Reproductive ecology- Sexual selection, Mating systems.
5. Reproductive strategies - timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict.
6. Population structure – processes
7. Life history characteristics
8. Models of Population Change- Exponential and Geometric Models, Logistic Model
9. Complex Models, Computerized Models

10. Biogeography – Wallace realms – Island biogeography theory
11. Spatial dynamics – Models of spatial dynamics
12. Use of GIS – Raster model and Vector model.
13. Ecosystem structure – energy flow
14. Biogeochemical cycles – Hydric cycle, nitrogen cycle
15. Biogeochemical cycles – Carbon cycle and others
16. Climate modification by organisms
17. **Mid semester examination**
18. Herbivory, pollination – their functional groups, measurement, effects.
19. Seed predation and dispersal - their functional groups, measurement, effects.
20. Decomposition - their functional groups, measurement, effects.
21. Biodiversity and Conservation- Ecological Indicators.
22. Role of insects as ecosystem regulators – NPP regulation by insects.
23. Development of IPM concept.
24. Behaviour**-** History of Ethology- development of ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz.
25. Studying behaviour- Proximate and Ultimate approaches.
26. Behavioural traits under natural selection.
27. Genetic control of behaviour and behavioural polymorphism.
28. Orientation- Forms of primary and secondary orientation including taxes and kinesis.
29. Communication- primary and secondary orientation.
30. Responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication.
31. Use of signals in defence, mimicry, polyphenism.
32. Evolution of signals. Behaviour in IPM**-** Concept of super-normal stimuli.
33. Behavioural manipulation as potential tool in pest management.
34. Use of semio-chemicals, auditory stimuli and visual signals in pest management.

PRACTICAL SCHEDULE

1. Assessmentof distribution parameters, Taylor's power law, Index of Dispersion, etc.
2. Assessment of resource size by female insects using a suitable insect model.
3. Construction of Life tables.
4. Working out Lotka-Volterra competition model, Shannon – Weiner Index, Species evenness index.
5. Hands on experience in building raster and vector models. Visit to Department of Earth sciences, Annamalai University.
6. Studies on insect biodiversity in a natural ecosystem.
7. Collection and identification of ecological indicator insects in various ecosystems.
8. Collection and identification of pollinators and their pollinating plants.
9. Collection and identification of decomposers and evaluating their role.
10. Natural ecosystem characterization I – Pond ecosystem.
11. Natural ecosystem characterization II – Forest ecosystem.

12. Agro-ecological characterization.
13. Ecology based pest management protocols in various crop ecosystems.
14. Experiment on habituation in mosquito maggots.
15. Evaluation of different types of traps and lures with respect to signals.
16. Visit to different ecosystems for studying insect interactions.
17. **Practical examination**

COURSE OUTCOMES

CO 1: Understand basic concepts of ecology and role of physiology and behaviour in ecology of insects
CO 2: Describe population ecology, models spatial dynamics and use of GIS
CO 3: Discuss ecosystem structure and role of insects in ecosystem regulation
CO 4: Illustrate basic concepts in ethology, its approaches and orientation
CO 5: Explain communication in insects and the role of ethology in IPM

CO – PO mapping

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

Reference books and online resources

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ENT 813 ADVANCES IN STORAGE AND QUARANTINE ENTOMOLOGY (2+1)

LEARNING OBJECTIVES

- To expose the recent developments in the safe storage of commodities and management of insect pests in small scale and large godowns
- To acquaint quarantine procedures and legislations imposed for import and export of commodities

THEORY

UNIT I – Post harvest losses

Post-harvest losses of grains in India – Scientific or socio-economic factors responsible for grain losses. Physiochemical changes in grains due to various abiotic and biotic factors –Principles of safe grain storage. Ecology of insect pests of stored food commodities/ grains.

UNIT II – Storage structures

Types of grain storage structures- Traditional, improved and modern. Engineering practices for safe grain storage. Ideal seeds and commodities in storage conditions. Warehousing in India. Latest electronic detection gadgets for stored product pests and damaged produce.

UNIT III –Management techniques

Preventive and curative measures for management of stored product insects. Recent advances in non-chemical management of stored produce insects. CAP Storage and CAS/MAS of seeds and grains. Allelochemicals, pheromones and bio-control agents for stored pest management. Entoleter and accessories for grain storage. Fumigation methods and techniques in large godowns, containers and silos. Handling and safe use of pesticides in stored commodities. Residual effects of fumigants in storage. Molecular technique for detecting insecticide (phosphine) resistance in storage pests. Nanotechnology in stored pest control

UNIT IV – Principles of quarantine

Detection and disinfestation of pests in plant quarantine**.** Invasive pests of India and their management methods. Quarantine principles and applications. Legislations adopted in India and abroad. Phytosanitary certificate - Quarantine regulations of agricultural produce, seeds, plants and domestic materials in international sea ports and air ports.

Unit V –Quarantine regulations and procedures

Quarantine laws - Seed health laws. Seed/grain/food safety acts (national / international). Relation between food standards and quarantine entomology. WTO Regulations on import and export of biological control agents. Pest risk analysis for commodities of export and import.

PRACTICAL

Detection and estimation of infestation in important storage pests in variuos commodities of processed food. Estimation of uric acid content in stored produce. Estimation of field carry over damage in cereals and pulses. Determination of moisture content in grains. Gadgets and equipment used in detection of pests of stored produce and also infested commodities. Modern storage structures for small- and large-scale storage. Practicing CAS techniques – Fumigation techniques and their evaluation. Use of carbon-dioxide for the management of stored product pests. Molecular techniques for detecting insecticide (phosphine) resistance in storage pests. Treatment of packing materials and their effect on seed quality. Demonstration of IPM tactics in stored produce. Visit to ware houses (CWC/FCI), Quarantine stations or centers.

THEORY LECTURE SCHEDULE

1. Post-harvest losses of grains in India and abroad
2. Scientific or socio-economic factors responsible for grain losses
3. Physio-chemical changes of grains due to various abiotic and biotic factors
4. Principles of safe grain storage
5. Ecology of insect pests of stored food commodities/ grains
6. Types of grain storage structures- Traditional, improved and modern
7. Engineering practices for safe grain storage
8. Ideal seeds and commodities for long time storage
9. Warehousing in India and their management techniques
10. Latest electronic detection gadgets for stored product pests and damaged produce
11. Preventive and curative measures for management of stored product insects
12. Recent advances in non-chemical management of stored product insect pests
13. CAP, CAS/MAS storage and effect of Co_2 treatment onstored produce pests

14. Allelochemical attractants and repellents for stored product insect pest management
15. Pheromones and biocontrol agents for pest management in stored commodity
16. Entoleter and accessories for grain storage
17. **Mid -Semester Examination**
18. Fumigation of large godowns and silos using various equipment
19. Methods adopted for fumigation by fumigation services in containers and large silos
20. Handling and safe use of pesticides in stored commodities
21. Residual effects of fumigants in stored produce
22. Molecular technique for detecting insecticide (phosphine) resistance in storage pests
23. Nanotechnology in stored product pest management
24. Detection and disinfestation of pests in plant quarantine
25. Invasive pests of India and their management methods
26. Principles of quarantine measures adopted in India.
27. Domestic and international quarantine measures against insect pests
28. Phytosanitary certificate - Procedure and necessity
29. Quarantine restrictions in the movement of agricultural produce, seeds and planting materials
30. Quarantine laws – Seed and Seed health laws
31. Seed/grain/food safety acts (national / international)
32. Relation between food standards and quarantine entomology
33. WTO Regulations on import and export of biological control agents
34. Pest risk analysis for commodities of export and import

PRACTICAL SCHEDULE

1. Detection of infestation of important storage pests in different commodities
2. Estimation of losses caused by important storage pests
3. Estimation of uric acid content in stored produce
4. Field carry over damage in cereals and pulses
5. Determination of moisture content in grains
6. Gadgets and equipment used in detection of pests of stored produce and also infested commodities.
7. Modern storage structures for small- and large-scale storage.
8. Practicing CAS techniques
9. Fumigation techniques and their evaluation in storage.
10. Method of using carbon-dioxide for the management of stored product pests
11. Molecular technique for detecting insecticide (phosphine) resistance in storage pests
12. Treatment of packing materials and their effect on seed quality
13. Detection of residues of chemicals in stored produce.
14. Demonstration of IPM tactics in stored produce.
15. Visit to ware house (CWC/FCI)
16. Visit to Quarantine stations or centers.
17. **Practical Examination**

COURSE OUTCOMES

CO 1: Explain principles involved in stored grain pest management and impact of biotic and abiotic factors
CO 2: Describe storage structures and latest electronic detection gadgets
CO 3: Discuss IPM of storage pest management and molecular techniques for detecting insecticide resistance
CO 4: Aware about quarantine principles and regulations
CO 5: Understand pest risk analysis and WTO regulations

CO – PO MAPPING

COs / POs	PO 1	PO 2	PO 3	PO4
CO 1	3			3
CO 2	3	3	3	3
CO 3	3	3	3	3
CO 4	3			3
CO 5	3	3		3

Suggesting Readings

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ENT 814 INSECT SYSTEMATICS AND IMMATURE INSECTS (1+2)

LEARNING OBJECTIVE

- To expose the scholars to different schools of classification, conventional and molecular methods of Taxonomy

- To expose the scholars to different stages of immature insects of agricultural importance

THEORY

Unit I History

History of Insect systematics- different schools of classification of insects- use of Phenograms, Cladograms and molecular approaches for classification of insects. Zoogeography, Evolution of insects- different views. Theories of origin of insects – Handlirisch's theory, Snodgross's theory, Brauer's theory, Fox and Fox's theory and Ross theory.

Unit II Evolution & Speciation

Fossil insects and evolution of insect diversity over geological times. Species concept- Biological and evolutionary concepts. Speciation- Allopatric- parapatric- Alloparapatric, Stasipatric and Sympatric speciation. Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN-Ethics.

Unit III Traditional vs Modern Taxonomy and websites

Insect Taxonomy and computers, Numerical Taxonomy, Chaetotaxonomy, Cytotaxonomy, Protein Taxonomy, Molecular Taxonomy, Bar coding of insects. Websites related to various groups of insects.

Unit IV Immature insects

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

Unit V Collection, preservation, and identification of immatures

Types of immature stages; their collection, rearing and preservation. Identification of immature insects up to family level, in exopterygote and endopterygote orders using keys.

PRACTICAL

Types of keys and use of keys in identification of insects – preparation of keys – procedures in description of species; practicing Chaetotaxonomy, Numerical Taxonomy; Electrophoretic technique in insect molecular taxonomy; Preparing specimens for SEM and TEM and practicing use of SEM in insect taxonomy. Collection and preservation of immature stages of insects - Preparation of immature insects for identification - Identification and classification of immature stages of

Ephemeroptera, Plecoptera, Odonata, Hemiptera, Diptera, Lepidoptera, Trichoptera, Hymenoptera, Neuroptera and Coleoptera up to family level. Visit to various ecosystems including hill and forest eco-system for collection of immature insects.
Assignment: Submission of at least 50 numbers of various immature stages of insects

THEORY LECTURE SCHEDULE

1. History of insect Systematics in India and abroad
2. Use of Phenograms, Cladograms and molecular approaches for classification
3. Zoogeography, insect evolution and theories of insect origin
4. Fossil insects – evolution of insect diversity
5. Methods of production of new evolutionary lineages like Allopatry, etc.
6. ICZN
7. ICZN
8. **Midsemester examination**
9. Insect Taxonomy and computers, Websites related to Insect Taxonomy
10. Numerical Taxonomy, Chaetotaxonomy, Cytotaxonomy, protein taxonomy and molecular Taxonomy
11. Bar coding of insects
12. Diversity of eggs and pupae in insects of major orders
13. Diversity of larvae/nymphs in insects of major orders
14. Immature stages as ecological and evolutionary adaptations. Significance of immature stages for pest management
15. Keys for the identification of insect eggs
16. Keys for the identification insect larvae / nymphs
17. Keys for the identification insect pupae

PRACTICAL SCHEDULE

1. Types of keys and use of keys in identification of insects
2. Practicing various keys in identification of insect orders
3. Practicing various keys in identification of immature insects
4. Procedures in description of new species
5. Practicing Chaetotaxonomy
6. Practicing Numerical taxonomy
7. Practicing Cytotaxonomy
8. Preparing specimens for SEM and use of SEM
9. Preparing specimens for TEM and use of TEM
10. Practicing Protein taxonomy
11. Preparation and use of SDS-PAGE in insect Classification
12. Isolation of Insect DNA
13. Practicing Restriction endonuclease analysis in insect classification
14. Insect bar coding
15. Collection of eggs of insects

16. Processing of eggs of insects and identification
17. Collection of naiads of insects
18. Processing and identification of naiads
19. Collection of nymphs of (exopterygote) insects
20. Processing of nymphs of insects and identification
21. Collection of aquatic larvae of (endopterygote) insects
22. Collection of terrestrial larvae of endopterygote insects
23. Processing of larvae of insects and identification
24. Preparation of larval blowing and identification
25. Collection of various dipteran puparium from organic matter, processing and identification.
26. Collection and identification of neuropteran pupae
27. Collection of Lepidopteran and Coleopteran pupae, chrysalis and cocoons.
28. Collection and identification of immature stages of Hymenoptera
29. Identification and classification of egg stages of Ephemeroptera, Plecoptera, Odonata and Hemiptera using keys
30. Identification and classification of egg stages of Diptera, Lepidoptera, Trichoptera using keys
31. Identification and classification of nymphal stages of Ephemeroptera, Plecoptera, Odonata and Hemiptera using keys

COURSE OUTCOMES

CO 1: Understand the concepts and theories of systematics and origin of insects
CO 2: Gain expertise in species concept and ICZN
CO 3: Compare and contrast traditional and modern taxonomic concepts
CO 4: Describe immature stage morphology, adaptations and their role in pest management
CO 5: Expertise in keying out immature stages up to family level

CO – PO MAPPING

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

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ENT 821–EMERGING TRENDS IN PLANT RESISTANCE TO PESTS (2+1)

LEARNING OBJECTIVES

- To impart knowledge on the current status of resistance in crop plants
- To make students familiar with biotechnological approaches in HPR, development of transgenic plants.

THEORY

Unit I: Geneticsof resistance

Genetics and inheritance of crop resistance to insects, novel methods of breeding for resistance – problems and prospects. Stability of resistance – biotype development

and measures to combat biotypes – Contemporary approaches in screening for resistance

Unit II: Induced resistance

Induced resistance – Elicitors – Forms of IR – ISR, SAR – Mechanisms; Biochemistry of Induced resistance – Phytohormones – JA, SA Pathways- Role of endophytes. Field evaluation of elicitors in inducing resistance– evaluation of biophysical and biochemical factors, tri-trophic interaction involving crop plant, pest and natural enemy

Unit III: Molecular approachesin plant resistance

Molecular techniques – utilization of wild species – identification of genes responsible for resistance. Marker aided selection – Mapping populations, morphological, biochemical and molecular markers – molecular markers linked to insect resistance in different crops

Unit IV: Genetic Transformation of crops for insect resistance

Transformation of genes of interest – Genetic transformation protocols for various crops – BT toxins; Secondary plant metabolites -Protease inhibitors, alpha amylase inhibitors; enzymes - plant lectins and other agents – gene pyramiding

Unit V: Transgenic crops

Successful examples of transgenic crop varieties in India and world,Use of insect resistant transgenic crops for pest management - their status, scope and limitations. Transgenic resistance on non-target organisms, Development of resistance to transgenic plants and strategies to manage – Gene flow and its management

PRACTICAL

Mass culturing of selected homopteran and lepidopteran insects for screening. Field and glasshouse / laboratory evaluation of induced resistance in selected crops, Estimation of biophysical and biochemical factors of resistance. Evaluation of wild species of crops as sources of resistance,Estimation of secondary plant metabolites, evaluation of molecular markers, visit to state/national institutes to gain latest research developments in plant resistance to pests

THEORY LECTURE SCHEDULE

1. Genetic basis for resistance
2. Genetics and inheritance of resistance to insect pests in selected crops
3. Novel methods of breeding for resistance
4. Problems and prospects in various methods of breeding for resistance.

5. Stability of resistance – biotype development
6. Measures to combat biotypes
7. Contemporary approaches in screening for resistance
8. Induced resistance – Elicitors – Status and scope
9. Forms of IR – ISR, SAR – Mechanisms
10. Biochemistry of Induced resistance – Phytohormones – JA, SA Pathways
11. Role of endophytes and other elicitors in inducing resistance
12. Field evaluation of elicitors in inducing resistance
13. Evaluation of biophysical factors of induced resistance
14. Evaluation of biochemical factors of induced resistance
15. Tri-trophic interaction involving crop plant, pest and natural enemy
16. Molecular techniques in HPR– utilization of wild species
17. Identification of genes responsible for resistance
18. Mid-semester Examination
19. Marker aided selection – Mapping populations
20. Morphological, biochemical markers linked to insect resistance in different crops
21. Molecular markers linked to insect resistance in different crops
22. Gene synteny, molecular markers and metabolic pathways
23. Marker assisted versus phenotypic selection
24. Genetic transformation protocols for resistance to insect pests
25. Genetic transformation protocols for BT toxins
26. Genetic transformation protocols for Secondary plant metabolites - Protease inhibitors, alpha amylase inhibitors
27. Genetic transformation protocols for enzymes - plant lectins and other agents
28. Gene pyramiding
29. Successful examples of transgenic crop varieties in India and world
30. Use of insect resistant transgenic crops for pest management - their status, scope and limitations
31. Transgenic resistance on non-target organisms
32. Development of resistance to transgenic plants and strategies to manage
33. Bio-safety of food from genetically modified crops
34. Gene flow and its management

PRACTICAL SCHEDULE

1. Mass culturing of selected homopteran and lepidopteran insects for screening studies
2. Practicing induced resistance using organic inputs in rice / pulse / vegetables
3. Practicing induced resistance using microbial inoculants in rice / pulse / vegetables
4. Practicing induced resistance using micronutrients in rice / pulse / vegetables
5. Practicing induced resistance using phytohormones inputs in rice / pulse / vegetables
6. Evaluation of feeding preference towards induced and non-induced accessions – Free choice and confinement methods

7. Evaluation of ovipositional preference towards induced and non-induced accessions – Free choice and confinement methods
8. Evaluation of orientation towards induced and non-induced accessions using olfactometer
9. Evaluation of survival and developmental indices of selected insects on induced and non-induced accessions
10. Estimation of diversity and density of trichomes on induced and non-induced accessions
11. Estimation of impedance to movement on induced and non-induced accessions
12. Estimation of entrapment on induced and non-induced accessions
13. Evaluation of biochemical constitution of induced and non-induced accessions
14. Evaluation of wild species of certain crop plants for resistance traits
15. Practicing estimation of molecular markers in selected crops
16. Visit to state/national institutes
17. Practical Examination

COURSE OUTCOMES

CO 1: Understand the Genetics of resistance and novel methods of breeding for resistance,biotype development and measures to combat biotypes.
CO 2: Capable to explain about the Induced resistance, Phytohomones and tri-trophic interaction involving crop plant, pest and natural enemy
CO 3: Describe about the Molecular approaches in plant resistance and molecular markers linked to insect resistance in different crops
CO 4: Explain about the Genetic Transformation of crops for insect resistance and Secondary plant metabolites.
CO 5: Capable to utilizing the resistant varieties in IPM and explain about the methods in development of transgenic plants.

CO – PO MATRIX

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

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ENT 822 ADVANCES IN TOXICOLOGY OF INSECTICIDES AND BIORATIONALS (2+1)

LEARNING OBJECTIVES

- To Discuss in detail about the dynamic interactions of toxicants with a biological target and its effects in the environment
- To understand the principles and concepts about toxicodynamics and toxicokinetics
- To know the mode of action and environmental fate of toxicants

THEORY

UNIT I: Basics of target sites

Neurophysiology – integument physiology - endocrine physiology – chemistry and action of neurohormones and neuropeptides –ecdysteroids. Insecticides - growth regulators – botanicals – groups - chemistry- toxic syndromes in targets.

UNIT II: Toxicokinetics

Exposure -dose response relationship –NOEL- LOEL – median lethality concept – exposure assessment. Absorption – distribution - biotransformation – excretion.

UNIT III:Toxicodynamics

Penetration - biological effect – molecular, biochemical and physiological effects of toxicants - altered structure and function – risk assessment.

Unit IV:Mechanisms of action of insecticides & biorationals

GABA Receptors - Anticholinesterases - Voltage Gated Na and CI channels. Ligand gated channels - Nicotinic Acetylcholine Receptor (nAchR) - agonist and antagonist. Hormonal analogs - IGRs - interference in biosynthesis.

Unit V: Fate of toxicants in the environment

Metabolism - Phase 1 & II, ExtramicrosomalResistance development - Mechanisms: Reduced Penetration. Metabolic Resistance. Target site insensitivity. resistant management strategies - Insecticide Residues – Problems associated – Concepts developed – pesticides persistence and pollution; health hazards and other side effects -NOAEL, ADI, MRL, waiting period – Methods of determining them – Principles and methods of residue analysis.

PRACTICAL

Dissection to study nervous system in important groups of insects. Estimation of transmitter substance – LD_{50}, LC_{50} of parent compound and metabolites in selected groups of pesticides, Estimation of Glutothione SH (GSH) transferases, carboxyl esterase, MFO in insects.Bioassay techniques; Probit analysis; evaluation of insecticide toxicity and joint action synergism and antagonism.Working out doses and concentrations of pesticides; biochemical and biological techniques for detection of insecticide resistance in insects. Sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; Operation of Gas Chromatography (GC) and High-Pressure Liquid Chromatography (HPLC).

THEORY LECTURE SCHEDULE

1. Structure of nervous system
2. Function of nervous system
3. Types of nervous system
4. Nerve conduction
5. Function of integument
6. Chemistry of integument
7. Function of endocrine system
8. Chemistry and action of neurohormones
9. Chemistry and action of neuropeptides
10. Chemistry and action of ecdysteroids
11. Chemistry of newer insecticides,
12. Chemistry of growth regulators
13. Chemistry of botanicals
14. Toxic syndromes in target insects

15. Dose response relationship
16. Absorption, biotransformation and excretion.
17. **Mid semester examination**
18. Penetration of xenobiotics
19. Molecular effects of toxicants
20. Biochemical effects of toxicants
21. Physiological effects of toxicants
22. Risk assessment
23. Receptors in nerve function
24. Channels in nerve function
25. Hormonal analogs - interference in biosynthesis
26. Antifeedant
27. Metabolism - Phase 1 & II
28. Mechanisms of resistance development
29. Resistant management strategies
30. Insecticide Residues
31. Pesticides persistence
32. Pesticide pollution and health hazards
33. NOAEL, ADI, MRL, waiting period
34. Principles of residue analysis

PRACTICAL SCHEDULE

1. Dissection of grasshopper to study nervous system
2. Dissection of housefly to study nervous system
3. Estimation of nerve transmitter substance
4. Estimation of Glutothione SH (GSH) transferases,
5. Estimation of carboxyl esterase,
6. Estimation of MFO in insects.
7. Conducting bioassay
8. Probit analysis
9. Antifeedant assay
10. Evaluation of the action synergism
11. Working out doses and concentrations of pesticides
12. Working the Pesticides persistence
13. Biochemical techniques for detection of insecticide resistance in insects
14. Biological techniques for detection of insecticide resistance in insects
15. Sampling, extraction, clean-up of samples
16. Estimation of insecticide residues
17. **Practical Examination**

COURSE OUTCOMES

CO 1: Illustrate advanced knowledge in neuro physiology, endocrine physiology and actionof toxicants on these targets

CO 2: Explain concepts of toxicokinetics concepts NOEL, LD and bio transformation

CO 3: Describe molecular and physiological effects of toxicants and SAR

CO 4: Discuss Ion channel types and as targets of insecticides

CO 5: Explain degradation of insecticides in environment, plants and animals, resistance and residue management

CO – PO MAPPING

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

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ENT 823 ADVANCES IN BIOSUPPRESSION OF INSECT PESTS (2+1)

LEARNING OBJECTIVES

- To impart knowledge on the latest developments in bio-suppression in insect pest management
- To study the advanced techniques in the mass production of natural enemies.

THEORY

UNIT I – Biological control

Biological control - Scope of classical biological control and augmentative biocontrol. Handling and importation of natural enemies. Identification of natural enemies of major crop pests. Molecular tools for identification of natural enemies. Nutrition of entomophagousinsects and their hosts. Dynamics of biocontrol agents towards target pest populations.

UNIT II – Mass culture of natural enemies

Advances in mass culturing techniques of natural enemies – Facilities and basic standards required for establishing insectary. Establishment of viable mass production unit for natural enemies for commercial production. Quality assurance of natural enemies in the production unit. Tritrophic relationship of natural enemies with reference to biological control.

UNIT III – Formulation and release techniques

Formulation and economics of natural enemy production. Release and colonization techniques of natural enemies. Evaluation and augmentation of natural enemies. Survivorship analysis and ecological manipulations. Scope of genetically engineered microbes and parasitoids in biological control. Ideal traits in biocontrol agents for progeny selections and breeding of quality biocontrol agents.

UNIT IV – Semio-chemicals

Semio-chemicals in pest management – Pheromone synthesis and evaluation. Effect of selected pheromones of key pests of crops. Successful pheromones and their utilization in pest management.

UNIT V – Botanicals

Scope of botanicals in pest management. Successful native plant species utilized in IPM. Extraction methods and utilization of various formulations of pesticidal plant species for effective pest management. Pesticidal compounds of important plant species and their mode of action.

PRACTICAL

Molecular tools for identification of natural enemies. Mass production and release of indigenous natural enemies. Evaluation of efficacy of natural enemies in field condition. Testing side effects of pesticides on natural enemies. Effect of semio-chemicals on natural enemies. Breeding methods of various biocontrol agents. Record preparation for establishing mass

production unit/ insectary. Quality control in natural enemy production and marketing. Extraction and utilization of formulations of botanicals. Test the mode of action and efficacy of native plant species in the laboratory condition. Visit to Govt. or private biocontrol production unit/ NBAIR.

THEORY LECTURE SCHEDULE

1. Latest developments in biological control
2. Scope of classical biological control and augmentative bio-control
3. Handling and importation of natural enemies
4. Identification of natural enemies of major crop pests
5. Molecular tools for identification of natural enemies – DNA Barcoding
6. PCR – RFLP methods in natural enemy detection
7. Nutritional requirement for entomophagous insects
8. Nutrition for hosts of entomophagous insects during culturing
9. Dynamics of biocontrol agents towards target pest populations
10. Advances in mass culturing techniques of Predators
11. Advances in mass culturing techniques of Parasitoids
12. Advances in mass culturing techniques of Pathogens
13. Infrastructure facilities and basic standards required for establishing insectary.
14. Establishment of functional commercial production unit for natural enemies
15. Quality assurance of natural enemies in the production unit.
16. Tritrophic relationship of natural enemies in relation to biological control.
17. **Mid semester examination**
18. Formulations of successful pathogens.
19. Economics of natural enemy production in the laboratory
20. Release and colonization techniques of natural enemies in the field
21. Evaluation and augmentation of natural enemies in the field
22. Survivorship analysis and ecological manipulations of natural enemies
23. Scope of genetically engineered microbes in biological control
24. Genetically engineered parasitoids in biological control
25. Ideal traits for progeny selections, and breeding of quality biocontrol agents.
26. Scope of semio-chemicals in pest management
27. Pheromone synthesis and evaluation against key pests of crops
28. Successful pheromones of insects and their utilization in pest management
29. Chemical compounds of pheromones
30. Future of botanicals in pest management.
31. Successful native plant species utilized in IPM
32. Extraction methods of various formulations of pesticidal plant species
33. Utilization of botanicals towards organic pest management
34. Pesticidal compounds of important plant species and their mode of action

PRACTICAL SCHEDULE

1. Molecular methods in natural enemy identification
2. Recent techniques in the mass production of Parasitoids

3. Recent techniques in the mass production of Predators
4. Recent techniques in the mass production of Pathogens
5. Recent advances in the mass rearing of host insects of natural enemies
6. Latest release techniques of natural enemies in the field condition
7. Evaluation of efficacy of natural enemies in field condition.
8. Testing side effects of pesticides on natural enemies.
9. Breeding methods of various biocontrol agents.
10. Record preparation and maintenance of mass production unit/ insectary.
11. Quality control in natural enemy production and marketing.
12. Effect of selected pheromones in pest management
13. Extraction methods of various formulations of botanicals.
14. Test the mode of action and efficacy of native plant species in the laboratory condition.
15. Visit to Govt. or private bio-control agents production unit
16. Visit to NBAIR, Bangalore
17. Practical Examination

COURSE OUTCOMES

CO 1: Explain identification of natural enemies including molecular tools, role of nutrition and dynamics of natural enemies
CO 2: Describe the mass culturing techniques of natural enemies, their quality assurance and tritrophic interactions
CO 3: Details about formulation and field release techniques of natural enemies.
CO 4: Illustrate pheromone synthesis and evaluation
CO 5: Illustrate important species of plants, their extraction, formulations and use

CO – PO MAPPING

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

Suggested Readings

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ENT 824 ADVANCES IN NON-INSECT PEST MANAGEMENT

LEARNING OBJECTIVES

- To impart knowledge on the current status of non-insect pestin field and horticultural crops and their management

THEORY

Unit I Plant parasitic mites and their management

Comparative morphology of plant parasitic mites - phylogeny of higher categories in mites - Diagnostic characteristics of commonly occurring species of mites - Management of economically important species of mites in crops and storage - Mites as vectors of plant pathogens - mode of action, structure activity relationships of different groups of acaricides - problems of pesticide resistance in mites, resurgence of mites. Predatory mites, their mass production - acaropathogenic fungi- Identification, isolation and utilization.

Unit II Plant parasitic nematodes and their management

Economic importance of plant parasitic nematodes to agriculture - broad classification, nematode biology, physiology and ecology - Diagnosis of symptoms – casual organism - interaction of plant parasitic nematodes with plant pathogens - Plant nematode relationships, cellular responses to infection by phytonematodes;

physiological specialization among phytonematodes. Principles and practices of nematode management; integrated nematode management.

Unit III – Rodents and their management

Economic importance of rodents in Agriculture –Taxonomy and reproductive biology of rodents - Effect of changes in farming systems on rodent population dynamics - Association between damage to crops and density of rats - Population estimates and Behavior of rodents – Rodents as carrier of diseases – Rodent IPM – Ecological based integrated management at community level.

Unit IV Birds as pests and predators

Status of agricultural ornithology in India - groups of birds associated with agro - ecosystems. Habitat association of birds in both wet and dry agricultural systems. Pestiferous and depredatory birds associated with different crops and their management - Beneficial role of carnivorous birds in agriculture.

Unit V Domestic and wild animals as pests and their management

Domestic and wild animals as pests in Agriculture and Horticulture – their damage to crops – animal invasions – ecological considerations in animal raids – biological barriers – ethical issues in the management of animals in agriculture

PRACTICAL

Collection and identification of commonly occurring mites up to species using keys. Rearing phytoseiid mites and studying their role in suppression of spider mites - Management of mite pests of crops using acaricides – Extraction of plant parasitic nematodes from soil and plants – Practicing different methods of nematode management – Taxonomy of rodents and their biology – studies on rodent habitats – Integrated Rodent Management –community trap barrier system - Study of different groups of birds associated with agriculture and horticulture crops, their morphology and field identification - Study of nesting and roosting habits of birds in agricultural habitats - Study of different groups of domestic and wild animals associated with agriculture - their morphology and field identification – Study of animal raids - barriers for avoiding animals in Agriculture.

THEORY LECTURE SCHEDULE

1. Non-insect pests' damage in crops and their significance
2. Plant parasitic mites - comparative morphology of plant parasitic mites with insects and their classification - Phylogeny of higher categories in mites
3. Economically important species of mites in crops and storage and their management
4. Mites as vectors of plant pathogens
5. Acaricides – classification, mode of action and structure activity relationships of different groups
6. Pesticide resistance in mites, resurgence of mites - Predatory mites, their mass production

7. Acaro-pathogenic fungi-Identification, isolation and utilization.
8. Economic importance of nematodes in agriculture
9. Different classification of plant parasitic nematodes – Taxonomy of major plant parasitic nematodes
10. Nematodes of crops – damage and ecological relationship
11. Interaction of plant parasitic nematodes with other organisms – nematodes as vector of plant pathogens
12. Cellular responses to infection by important phytonematodes - physiological specialization among phytonematodes.
13. Components of nematode management - integrated nematode management
14. Economic importance of rodents in Agriculture –Taxonomy and reproductive biology of rodents
15. Effect of changes in farming systems on rodent population dynamics
16. Rodent damage and damage potential of rodents and association between damage to crops, stored grains and density of rats
17. **Midsemester examinations**
18. Population estimates and Behaviour of rodents
19. Rodents as carrier of diseases
20. Rodent management – Rodenticides – baits for rats
21. Ecologybased integrated rodent management at community level
22. Status of agricultural ornithology in India - groups of birds associated with agro -ecosystems
23. Habitat association of birds in both wet and dry agricultural systems
24. Pestiferous birds associated with different crops and their management
25. Depredatory birds associated with different crops and their management
26. Beneficial role of carnivorous birds in agriculture
27. Recent trends in bird pest management
28. Domestic and wild animals as pests in Agriculture
29. Different domestic animals and wild animals as pests of crops and their damage potential
30. Domestic animals' invasion in agricultural crops and their damage
31. Wild animal's invasion in horticultural crops and their damage
32. Animal raids and their considerations
33. Impact of biological barriers on the management of wild animals
34. Ethical issues in the management of animals in agriculture

PRACTICAL SCHEDULE

1. Collection and identification of plant parasitic mites using keys
2. Rearing phytoseiid mites and practicing management of spider mites
3. Practicing cultural, mechanical and chemical management of plant parasitic mites
4. Extraction of plant parasitic nematodes from soil
5. Extraction of plant parasitic nematodes from plants and roots
6. Practicing various cultural, physical, biological and chemical control of plant parasitic nematodes

7. Taxonomy of rodents and investigations on their habitats
8. Preparation of poison baits for rodent management and evaluation
9. Practicing community trap barrier system for rodent control
10. Practicing various traps for rat control and imparting knowledge on different rodenticides available in market
11. Study on different groups of birds associated with agriculture and horticulture crops
12. Pestiferous and depredatory birds - their morphology and field identification
13. Study of nesting and roosting habits of birds in agricultural habitats
14. Study of different group of domesticand wild animals and their associated damage to crops
15. Study of animal raids and barriers for avoiding animals in Agriculture and horticulture
16. Visit to various ecosystems for the collection of non-insect pests
17. Practical Examination

COURSE OUTCOMES

CO 1: Describe Comparative morphology of plant parasitic mites and their impact as vectors

CO 2: Discuss management of mites

CO 3: Discuss biology and management of rodents

CO 4: Describe role of birds as pests

CO 5: Illustrate the importance of Domestic and wild animals as pests in Agriculture and Horticulture

CO – PO MAPPING

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

References

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2. Bridge, J. and J.L. Starr. 2007.Plant nematodes of Agricultural importance. Manson Publishing Ltd., London, UK. p.152. ISBN 9781840760637
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4. Ciancio, A. and A. Mukerji. 2008. Integrated management and biocontrol of vegetable and grain crops nematodes. Springer, Netherlands. p.356. ISBN – 978-1-4020-6062-5 DOI : 10.1007/978-1-4020-6063-2

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6. Ritika, B. and U. Dey. 2014. Non insect pests damaging to Agricultural Crops. Lambert Academic Publishing. p.104. ISBN: 9783848449590
7. Stanley, J. 2015. Animal and bird pest management in Agricultural land. Daya Publishing House, New Delhi. p.138.
8. Vacante, V. 2015. The handbook of mites of economic plants. CABI. p.890 ISBN: 9781845939946

Web resources

1. Non-insect pests of Agricultural importance - http://www.egyankosh.ac.in/bitstream/123456789/13932/1/Unit-4.pdf
2. Different non-insect pests :http://www.skynetplanet.com/different-non-insect-pests-birds-rodents-crabs-and-snails/

MINOR COURSES

ENT 815 ENTREPRENEURIAL ENTOMOLOGY (2+1)

LEARNING OBJECTIVES

- To impart practical knowledge on various entrepreneurial avenues related to entomology
- To instil confidence among students to start entrepreneurial ventures.

THEORY

Unit I

Scope of Entomology in commerce – Contribution of insects towards national GDP – Entomological avenues for commercial resource generation –insect products and services, global and Indian status.

Unit II

Apiculture and sericulture as industry – Products - New Venture Creation – requirements for starting a viable unit – major markets - Role of research and training institutes– Cost economics – Pilot project proposal development for credit mobilization

Unit III

Insects as service providers – Bio control Agents production facility – novel formulations of microbial insecticides and phyto-insecticides - designing a pilot plant - Licensing protocols - Cost economics – Micro Planning and credit mobilization

Unit IV

Commercial pest control operations – Opportunities and constraints - Licensing protocols – Target customers in Tier I and Tier II cities – developments in the past decade, future potential – Termite control operations – Vectors – Mosquito, Bedbug – their management - Nuisance pests – cockroach, ants– their management - Cost economics

Unit V

Insects as animal feed - Opportunities and constraints – World status and Indian requirements – Insects used – Biology, methods of culturing – Process and products – Successful examples from around the world- Relevance to Poultry industry. Entomophagy -Importance and prospects.

PRACTICAL

Basic Honeybee rearing technique, Silkworm rearing technique. Project proposal writing. Working out cost benefit ratio and break-even point. Visit to apiculture and sericulture units. Basic idea about various bio control agents and their production. Detailed study on licensing protocols. Pilot project preparation. Credit mobilization process. Studies on Novel formulations developed. Various termite control operations. Identification and management of vectors. Identification and management of Nuisance pests. Licensing protocols for commercial pest control operators. Working out cost economics. Identification of various insects used as animal feed. Studies on culturing of the insects. Processing of insects as animal feed products.

THEORY LECTURE SCHEDULE

1. Scope of Entomology in commerce – Contribution of insects towards national GDP
2. Entomological avenues for commercial resource generation
3. Insect products and services, global and Indian status.
4. Apiculture and sericulture as industry
5. Products –Apiculture & Sericulture - New Venture Creation
6. Requirements for starting a viable unit
7. Major markets - Role of research and training institutes
8. Cost economics of Apiculture / Sericulture units
9. Pilot project proposal development for credit mobilization
10. Insects as service providers
11. Bio control Agents production facility
12. Novel formulations of microbial insecticides and phyto-insecticides
13. Designing a pilot plant
14. Licensing protocols
15. Cost economics of bio control agents production facility
16. Micro Planning and credit mobilization
17. **Mid semester examination**
18. Commercial pest control operations - Opportunities and constraints
19. Licensing protocols
20. Target customers in Tier I and Tier II cities
21. Developments in the past decade, future potential
22. Termite control operations
23. Vectors - their biology and management
24. Nuisance pests their management
25. Cost economics of pest control operations

26. Insects as animal feed - Opportunities and constraints
27. World status and Indian requirements
28. Insects used as animal feed their methods of culturing
29. Insects as animal feed - Processing and products
30. Successful examples from around the world
31. Relevance to Poultry industry
32. Cost economics of insect culturing for animal feed
33. Pilot project proposal writing
34. Entomophagy – importance and prospects

PRACTICAL SCHEDULE

1. Hands on training in Honeybee rearing technique,
2. Hands on training in Silkworm rearing technique.
3. Project proposal writing and Working out cost benefit ratio and break-even point.
4. Visit to apiculture and sericulture units.
5. Basic idea about various bio control agents and their production.
6. Detailed study on licensing protocols.
7. Pilot project preparation and Credit mobilization process.
8. Visit to bio control agent production facility
9. Termite control operations – Pre-treatment techniques.
10. Termite control operations – Post -treatment techniques.
11. Identification and management of vectors and Nuisance pests.
12. Licensing protocols for commercial pest control operators.
13. Working out cost economics.
14. Visit to Pest control operation facility
15. Identification of various insects used as animal feed.
16. Studies on culturing of the insects and processing of insects as animal feed products.
17. **Practical examination**

COURSE OUTCOMES

CO 1: Describe the scope of entomology in commerce and understand the contribution of insects to national GDP
CO 2: Discuss the cost benefit analysis of apiculture and sericulture and development of pilot project development and credit mobilization
CO 3: Explain bio control lab establishment requirements and discuss credit mobilization and pilot project preparation
CO 4: Illustrate the importance of pest control operations in cities and opportunities
CO 5: Discuss the role of insects as animal feed and its relevance to poultry industry

CO – PO MAPPING

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

Reference books and online resources

1. http://ndpublisher.in/admin/issues/EAv63n1zh.pdf
2. Jolly, M.S. 1986. Economics of Sericulture under irrigated conditions. CSRTI. Mysore. 23p. (Reference for Cost benefit skeleton)
3. http://vikaspedia.in/agriculture/farm-based-enterprises/sericulture/economics-of-cocoon-production
4. https://www.banglajol.info/index.php/BJAR/article/download/11176/8163
5. http://ppqs.gov.in/divisions/cib-rc/guidelines
6. http://dhruvcropprotection.com/cibrc.html
7. Dalip,K. 2016. Pest management operators training manual. IICA. Europe. 68p.
8. Burns, D. and Stapleton, K. 1995. Structural Pest Control Pesticide Safety Manual 1stEdition. Canada. 212p.
9. http://www.fao.org/docrep/018/i3253e/i3253e07.pdf
10. http://www.fao.org/3/a-au189e.pdf
11. Huis, A.V.,Itterbeeck, J.V.,Klunder, H., Mertens, E., Halloran, A., Muir, G. and Vantomme, P. 2013. Edible insects: future prospects for food and feed security.FAO., Rome.201p.http://www.fao.org/docrep/018/i3253e/i3253e.pdf

ENT 825- INSECT PESTS MANAGEMENT IN ORGANIC FARMING (2 + 1)

LEARNING OBJECTIVES

- To understand the importance and scope of pest management in organic farming.
- To acquaint with various strategies in organic pest management
- To understand various input certification standards

THEORY

Unit I: Principles of organic farming

Organic farming – Definition – History- Current status, scope and importance. Basic requirements- role in agro eco system-strategies and components- Role of tribal knowledge in organic forming

Unit II: Cultural and traditional strategies

Cultural practices – various methods- crop rotation, crop isolation, soil management, crop residue management, weed management, scientific validation – Traditional varieties of major crops – resistance properties. Traditional storage structures – Rodent management.

Unit III: Ecological engineering strategies

Ecological engineering – Importance - Role of conservation of natural enemies in pest management – Beetle bank -Weed strips – Pollen producing ground cover - Cropping systems – Trap and intercropping – Push and Pull strategy – successful examples – limitations. Importance of community approach in implementation of ecological engineering.

Unit IV: Biological, botanical and behavioural strategies

Entomophages and entomopathogens in organic pest control –Different types. General principles of mass production. Application of bacterial, viral, myco insecticides and entomophages – Role of insectivorous birds in pest management - Importance of insecticides of plant origin – Plant extracts and their preparation– application – Shelf life and storage - Use of pheromones and other traps in pest management.

Unit V: Permitted pest management inputs

Organic certification Standards – NPOP, NOP, JAS, and European standards - Permitted inputs for pest management under various standards with emphasis on NPOP – APEDA - Certification agencies – Input approval criteria - Current status of organic pest management inputs in the market – Marketing and scope of certified organic inputs.

PRACTICAL

Introduction to pests and basic principles of pest management excluding chemicals – Various cultural practices for pest management – Studying characters of resistant varieties of important crops – Agro ecosystem survey analysis – Study of various inter cropping and trap cropping systems – Identification of refugia crops in important crop ecosystems and traditional pest management methods - Practicing conservation techniques of natural enemies – Identification of important entomopathogens, predators, parasitoids and insectivorous birds by their common names – Brief mass production procedure for green lace wings, Coccinellids, *Trichogramma* – Brief mass production procedure for NPV, mycoinsecticides and Bt – Identification of plants used as insecticides- Preparation of popular botanical insecticides, their application – Traps and pheromones in organic pest management

– Studying organic certification standards – Market analysis of certified organic inputs – visit to organic farms practicing pest management.

THEORY LECTURE SCHEDULE

1. Organic farming – Definition – History - Current status, scope and importance.
2. Requirements for organic pest managements.
3. Role played in agro eco system.
4. Strategies and components of organic pest management.
5. Role of tribal knowledge in organic forming.
6. Cultural practices.
7. Role of crop rotation, crop isolation and soil management.
8. Role of crop residue management, weed management, field localization, tillage.
9. Scientific validation of cultural methods
10. Traditional varieties of major crops and their resistant properties.
11. Advantages and disadvantages of cultural practices.
12. Traditional storage structures
13. Rodent management.
14. Ecological engineering - Definition and importance.
15. Role of conservation of natural enemies in pest management – Beetle bank - Weed strips – Pollen producing ground cover.
16. Cropping systems – Trap and intercropping.
17. **Mid semester examination.**
18. Push – Pull strategy – successful examples – limitations.
19. Importance of community approach in implementation of ecological engineering.
20. Entomophages and entomopathogens in organic pest control –Different types.
21. General principles of mass production.
22. Application of bacterial, viral and myco insecticides.
23. Application of entomophages.
24. Role of insectivorous birds in pest management.
25. Importance of insecticides of plant origin – Examples.
26. Plant extracts and their preparation.
27. Plant extracts application, Shelf life and storage.
28. Use of pheromones and other traps in pest management – Importance.
29. Organic certification Standards – NPOP, NOP, JAS, and European standards.
30. Permitted inputs for pest management under various standards with emphasis on NPOP.
31. APEDA - Certification agencies.
32. Organic input approval criteria.
33. Current status of organic pest management inputs in the market.
34. Marketing and scope of certified organic inputs.

PRACTICAL SCHEDULE

1. Introduction to pests and basic principles of pest management excluding chemicals.
2. Practicing various cultural practices for pest management.
3. Studying characters of resistant varieties of important crops.
4. Agro ecosystem survey analysis.
5. Study of various inter cropping and trap cropping systems.
6. Identification of refugia crops in important crop ecosystems.
7. Studying traditional pest management methods.
8. Practicing conservation techniques of natural enemies.
9. Identification of important entomopathogens, predators, parasitoids and insectivorous birds by their common names.
10. Brief mass production procedure for green lace wings, Coccinellids and *Trichogramma.*
11. Brief mass production procedure for NPV and mycoinsecticides.
12. Brief mass production procedure of *Bt*.
13. Identification of plants used as insecticides.
14. Preparation of popular botanical insecticides, their application.
15. Traps and pheromones in organic pest management.
16. Studying organic certification standards and Market analysis of certified organic inputs zero budget farming
17. Visit to organic farms and agencies involved in promotion of organic farming.

COURSE OUTCOMES

CO 1: Understands the scope and importance of organic farming, pest management related challenges in organic farming and role of tribal knowledge
CO 2: Describe cultural and traditional pest management activities and their impact
CO 3: Demonstrate ecological engineering tactics in conservation, augmentation of natural enemies and deterrence of pests
CO 4: Explain bio rational pest management options for organic pest management
CO 5: Discuss the legislation, certification and agencies involved in organic certification process.

CO – PO MAPPING

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

Reference books:

1. Altieri, M.A., C.I. Nicholls and M.A. Fritz. 2014. *Manage insects on your farm - A Guide to Ecological Strategies*, Sustainable Agriculture Research and Education (SARE) College Park, Maryland, USA, 146 p.
2. Directorate of Plant Protection, Quarantine and Storage. 2014. *Standard Operating Procedures (SOP) for Integrated Pest Management* (IPM) - Technical manual, Directorate of Plant Protection, Quarantine and Storage, 144 p.
3. Gurr, G.M., S.D. Wrattenand M.A. Altieri.2004. *Ecological Engineering for Pest Management: Habitat Manipulation for Arthropods*, CSIRO Publishing, Collingwood, Australia. 238 p.
4. Gurr, G.M., S.D. Wratten and W.E. Snyder. 2012. *Bio diversity and insect pests: Key issues for Sustainable Management*, Wiley – Blackwell, USA, 360 p.
5. Khetan, S.K. 2005. *Microbial Pest Control*, Marcel Dekker, New York, 320 p.
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7. Radcliffe, E.B., W.B. Hutchison and R.E. Cancelado. 2009. *Integrated Pest Management Concepts, Tactics, Strategies and Case Studies,* Cambridge University Press, UK. 529 p.
8. Vacante, V. and S. Kreiter. 2017. *Handbook of Pest Management in Organic Farming*, CABI, London, 576 p.
9. Yadav, A.K. 2005. *Training Manual on Certification and Inspection Systems in Organic Farming in India*, National Centre of Organic Farming, Ghaziabad, 45 p.

E-resources

1. APEDA. 2005. Certification manual - NPOP 2005. http://www.apeda.gov.in/apedawebsite/organic/organic_contents/english_organic_sept05.pdf
2. https://www.sare.org/Learning-Center/Topic-Rooms/Organic-Production/Organic-Pest-Management
3. http://bit.ly/ipmwebinars
4. http://ageconsearch.umn.edu/bitstream/120916/2/GurrWrattenAltieri02.pdf
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2610173/

SUPPORTING COURSES

COM 811 ADVANCES IN COMPUTING APPLICATIONS (0+1)

Learning Objectives

1.To understand the concepts of computer , to get knowledge in office like MS Word , MS Excel, SPSS, Html and Multimedia Applications.

2.To make them acquire sound knowledge in various Agricultural statistical software and their analysis.

3.To improve knowledge to get exposed to the current trends in Internet and their usage.

Practical Schedule:

1. Ms word –Creating a Mail Merge and Label
2. Ms Excel -Statistical Function and Data Analysis
3. Mean, Median, Variance, Standard Deviation, Correlation, Histogram
4. Ms-Access –Database Creation
5. Query Execution and Report generation
6. Multimedia Applications
7. Text Animating
8. Morphing
9. Creation of Webpage
10. Webpage creation using basic HTML tags ,Hyperlink and Images
11. Introduction to Artificial Intelligence in Agriculture
12. Statistical Analysis using SPSS
13. Factor analysis
14. Cluster analysis
15. Discriminant analysis
16. Multidimensional scaling
17. Exposure to Internet and research analysis

COURSE OUTCOME

1. Performing common basic functions like editing, formatting, printing, scanning etc using tools.
2. Create and populate a Ms-Access for a real life application, with constraints and keys, using SQL.
3. Able to describe and appreciate the applications of multimedia and identify different types of multimedia elements.
4. Understand how to start SPSS
5. Define a variety of statistical variables and enter basic data into SPSS

PO-CO MAPPING MATRIX

COs / POs	**PO 1**	**PO 2**	**PO3**	**PO 4**
CO 1	**2**			
CO 2				**2**
CO 3				**2**
CO 4				**3**
CO 5				**2**

References:

1. Kathy Jacobs. 2007. Microsoft Office Excel, The L line The Express line to Learning, Wiley, India Publications.
2. TNAU.2004. Advanced Quantitative Techniques and Data Analysis "Training Manual – Agrl. Engineering College and Research Institute, Coimbatore.
3. Darren George and Paul Mallery. 2009. "SPSS for Windows "Pearson Education, London.
4. Thomas Powell. 2010. HTML and CSS The Complete Reference, Fifth Edition, Tata Mc Graw Hill Publishing Company Limited, New Delhi.
5. http://en.wikipedia.org/wiki/Internet.

LIS 812 ADVANCES IN AGRICULTURAL INFORMATION RETRIEVAL (0+1)

LEARNING OBJECTIVE

- Students will acquire knowledge on importance of information centers for agricultural research
- To obtain awareness on KVK library in Information Transfer Process
- To equip knowledge on Institutional Repository of Indian National Agricultural Research System
- To gain familiarity on Consortium for e-Resources in Agriculture (CeRA)
- To develop knowledge and skills an agricultural databases

PRACTICAL

Information centers for agriculture development; Agricultural information services, Search engines, Library websites – Institutional Repository

Digital Libraries for agricultural development - Role of KVK library in Information Transfer Process - Library Consortium- Information Library Network (INFLIBNET); National Institute of Science Communication and Information Resources (NISCAIR)

Web of Science; Impact Factor- Scopus - H index; Indian Council of Agricultural Research (ICAR), Krishkosh - An Institutional Repository of Indian National Agricultural Research System, **AGRIC**ultural **O**n**L**ine **A**ccess (AGRICOLA), Access to Global Online Research in Agriculture (AGORA)

Consortium for e-Resources in Agriculture (CeRA), Centre for Agriculture and Bioscience International (CABI); e-resources access search methods.

PRACTICAL SCHEDULE

1. Information center for agriculture development
2. Agricultural information services
3. Search engines, Library websites
4. Institutional Repository
5. Digital Libraries for agricultural development
6. Role of KVK library in Information Transfer Process
7. Library Consortium

8. Directory of open access journals (ODAJ)
9 **Mid- Semester**
10. INFLIBNET
11. **National Institute of Science Communication and Information Resources (NISCAIR)**
12. Web of Science - Impact factor
13. Scopus - H index
14 **Indian Council of Agricultural Research (ICAR)**
15 Institutional Repository of Indian National Agricultural Research System (Krishkosh)
16 **AGRIC**ultural **O**n**L**ine **A**ccess (AGRICOLA)
17 Access to Global Online Research in Agriculture (AGORA)
18 Consortium for e-Resources in Agriculture (CeRA), CABI

COURSE OUTCOMES:

CO 1: The course outcome will acquire knowledge on importance of information centers for agricultural research

CO 2: The course outcome will augment the knowledge on KVK library in Information Transfer Process

CO 3: The course outcome will able to Institutional Repository of Indian National Agricultural Research System

CO 4: The course outcomes will familiarity on Consortium for e-Resources in Agriculture (CeRA)

CO 5: The course outcome will fortify the students to develop knowledge and skills and agricultural database

CO-PO MAPPING

COs/POs	PO 1	PO 2	PO 3	PO4
CO1	2			
CO2	2			
CO3		3		
CO4	2			
CO5		2		

References

1. Berners-Lee, T.1999; Weaving the Web. London: Orion business books. 1999.
2. Burnett, Robert and Marshall P David. 2003; Web theory: An introduction. London: Routledge.
3. Cheung. A home on the web: Presentations of self on personal homepages. (In:Guantlett, D: Web studies : Rewiring media studies for the digital age. London: Arnold 2000)
4. Herman and Swiss T, eds. The World Wide Web and contemporary cultural theory. New York. Routledge, 2000
5. Jones S G. ed. Virtual culture: Identity and communication in cyber society. London. Sage publications, 1997

Websites

1. https://doaj.org/
2. http://www.niscair.res.in/
3. https://icar.org.in/
4. http://krishikosh.egranth.ac.in/
5. https://library.udel.edu/databases/agricola/
6. http://cera.iari.res.in

STA 821 ADVANCES IN DESIGN OF EXPERIMENTS (2+1)

LEARNING OBJECTIVES

- The students will acquire sufficient basics of Statistical methods.
- To help them in understanding the concepts involved in data collection, presentation analysis and interpretation of results.
- To enhance the knowledge of students pertaining to testing Statistical Hypothesis.
- To acquire Multivariate Statistical Analysis skills.
- The students would be exposed to concepts of design of experiments.

THEORY

Unit–I: Sampling Techniques

Concept of sampling: Sampling vs complete enumeration. Planning of sample survey. Sampling from a finite population. Simple random sampling. Inverse sampling. Stratified sampling. Cluster sampling. Systematic sampling. Multistage sampling. Double sampling. Ratio and regression method of estimation. Non-sampling errors. Concept and levels of measurement. Non-parametric tests - Sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

Unit–II: Statistical Methods

Classification, tabulation and graphical representation of data. Descriptive statistics. Theory of probability. Random variable and mathematical expectation. Box-plot. Probability distributions: Binomial, Poisson, Negative binomial, Normal distributions and their applications. Concept of sampling distribution: t, chi-square and F distributions. Tests of significance based on normal, t, chi-square and F distributions.

Unit–III: Correlation and Regression Analysis

Correlation, Rank correlation, Correlation ratio, Intra-class correlation. Test of significance of correlation coefficient. Coefficient of determination.- Path analysis - Regression analysis, Partial and multiple correlation and regression. Estimation of parameters. Predicted values and residuals. Introduction to multivariate analytical tools. Test of hypothesis on means, Multivariate analysis of variance and covariance,

Cluster analysis, Classification by linear discriminant function, Canonical correlations, Principal components, Factor analysis, multi- dimensional scaling and Correspondence Analysis. Hierarchical clustering. Principal component analysis.

Unit–IV: Experimental Designs

Need for design of experiments, characteristics of a good design. Basic principles of designs - randomization, replication and local control. Uniformity trials, size and shape of plots and blocks; Analysis of variance and covariance; partitioning of degrees of freedom - Completely randomized design, randomized block design and Latin square design.

Unit–V: Factorial Experiments

Factorial experiments : Layout and analysis of factorial experiments – complete block design – split – plot design : strip-plot design : split split –plot design. Resolvable block designs and their applications. Randomization procedure, analysis and interpretation of results. Analysis of covariance. Missing plot technique and its application to RBD, LSD. Factorial experiments (symmetrical as well as asymmetrical). Factorial experiments with control treatment. Groups of experiments. Transformation of data.

PRACTICAL

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution. Correlation and regression analysis. Fitting of orthogonal polynomial regression. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests. Analysis of data obtained from CRD, RBD, LSD. Analysis of Covariance, Analysis of factorial experiments without and with confounding, Analysis with missing data. Split plot and strip plot designs. Groups of experiments, Transformation of data. Exercises on various Non-parametric tests; Random sampling, Use of random number tables, Simple random sampling, Determination of sample size, Exercises on Inverse sampling, Stratified sampling, Cluster sampling and Systematic sampling, Estimation using Ratio and regression estimators, Estimation using Multistage design and Double sampling.

THEORY LECTURE SCHEDULE

1. Classification, tabulation and graphical representation of data.
2. Descriptive statistics.
3. Theory of probability. Random variable and mathematical expectation.
4. Box-plot. Probability distributions: Binomial, Poisson, Negative binomial.
5. Normal distributions and their applications.
6. Concept of sampling distribution: t, chi-square and F distributions.
7. Tests of significance based on normal, t, chi-square and F distributions.
8. Correlation, Rank correlation, Correlation ratio.
9. Intra-class correlation. Test of significance of correlation coefficient.

10. Coefficient of determination.
11. Path analysis.
12. Regression analysis.
13. Partial and multiple correlation and regression.
14. Estimation of parameters. Predicted values and residuals.
15. Introduction to multivariate analytical tools.
16. Test of hypothesis on means, Multivariate analysis of variance and covariance.
17. Cluster analysis, Classification by linear discriminant function.
18. Canonical correlations, Principal components.
19. Factor analysis, multi- dimensional scaling and Correspondence Analysis.
20. Hierarchical clustering.
21. Principal component analysis.
22. Need for design of experiments, characteristics of a good design.
23. Basic principles of designs - randomization, replication and local control.
24. Uniformity trials, size and shape of plots and blocks; Analysis of variance and covariance; partitioning of degrees of freedom.
25. Completely randomized design, randomized block design and Latin square design.
26. Factorial experiments : Layout and analysis of factorial experiments.
27. Complete block design – split – plot design.
28. Strip-plot design : split split –plot design.
29. Resolvable block designs and their applications.
30. Randomization procedure, analysis and interpretation of results.
31. Analysis of covariance. Missing plot technique and its application to RBD, LSD.
32. Factorial experiments (symmetrical as well as asymmetrical).
33. Factorial experiments with control treatment.
34. Groups of experiments. Transformation of data.

PRACTICAL SCHEDULE

1. Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests.
2. Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval.
3. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution.
4. Correlation and regression analysis.
5. Fitting of orthogonal polynomial regression.
6. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests.
7. Analysis of data obtained from CRD, RBD, LSD.
8. Analysis of Covariance.
9. Analysis of factorial experiments without and with confounding, Analysis with missing data.
10. Split plot and strip plot designs. Groups of experiments, Transformation of

data.

11. Exercises on various Non-parametric tests.
12. Random sampling, Use of random number tables, Simple random sampling, Determination of sample size.
13. Exercises on Inverse sampling, Stratified sampling.
14. Cluster sampling and Systematic sampling.
15. Estimation using Ratio and regression estimators.
16. Estimation using Multistage design and Double sampling.
17. Practical Examination.

Course Outcome

CO 1: The course outcome will reveal the knowledge of basic statistical methods.

CO 2: The course outcome will ensure the understanding the concept involved in Data Collection, Presentation, Analysis and Interpretation of results of Agricultural Sciences.

CO 3: The course outcome will support the students to do in testing of Statistical Hypothesis.

CO 4: The course outcome will convey the knowledge of students to do Multivariate Statistical Analysis.

CO 5: The course outcome will assist the students to design their experiments in Agricultural field and collect the experimental data for analysis.

PO-CO-Mapping Matrix

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

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