ANNAMALAI UNIVERSITY

(Accredited with 'A' Grade by NAAC)

FACULTY OF AGRICULTURE

(Accredited by ICAR)

DEPARTMENT OF GENETICS AND PLANT BREEDING

Academic Regulations and Syllabi

DOCTOR OF PHILOSOPHY IN GENETICS AND PLANT BREEDING

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

2022-2023 Onwards

COMMON REGULATIONS FOR ALL Ph.D. PROGRAMMES OF FACULTY OF AGRICULTURE

(*w.e.f. 2022-2023*)

1. DEFINITIONS

1.1 An **"Academic year"** shall consist of two semesters.

1.2 **"Semester"** means an academic term consisting of 110 instructional days excluding final theory examinations.

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

1.4 **"Credit hour"** means, one hour lecture plus two hours of library or homework or two and half hours of library/field practical per week in a semester.

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

1.6 "**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.

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

1.8 **"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.

1.9 **"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.

2. SYSTEM OF EDUCATION

2.1 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 2022-2023.

2.2 The semester system shall be followed for all the Ph.D. degree programmes. The duration of doctoral programmes is as follows:

2.2.1 The duration of the programme and the time for admission of thesis are counted from the date of provisional registration.

2.2.2 The minimum duration of the programme is three years and the maximum duration of the programme shall be seven years.

2.2.3 Break of study shall be granted up to a maximum period of one year and it can be done only after completing the course work. Such request shall be made in advance by scholar in writing with the recommendation of Supervisor, Head of the Department (HoD) and Dean,

Faculty of Agriculture and it should reach the Director, Directorate of Academic Research (DARE). The orders for the break of study shall be issued by the Director, DARE after assessing the need.

2.2.4 If prior permission is not sought and obtained, it will be considered as a case of discontinuation and action will be taken to cancel the registration of such scholars.

2.2.5 The scholars should remit the yearly fees during the break of study also.

3. PROGRAMMES OFFERED

The details of various Ph.D. programmes offered in the Faculty of Agriculture are as follows:

1. Agri Business Management
2. Agricultural Economics
3. Entomology
4. Agricultural Extension Education
5. Agricultural Microbiology
6. Agronomy
7. Genetics and Plant Breeding
8. Horticulture in Fruit Science
9. Horticulture in Vegetable Science
10. Horticulture in Floriculture and Landscaping
11. Horticulture in Plantation, Spices, Medicinal and Aromatic plants
12. Plant Molecular Biology and Biotechnology
13. Plant Pathology
14. Seed Science and Technology
15. Soil Science and Agricultural Chemistry

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.

Table 1: Eligibility Criteria

Doctoral Degree Programmes	Eligibility
1. Agri Business Management	MBA in Agribusiness / MBA Agri Business Management
2. Agricultural Economics	M.Sc. (Ag.) in Agrl. Economics / Agricultural Marketing Management
3. Entomology	M.Sc. (Ag.) in Entomology / Agricultural Entomology

4. Agricultural Extension Education	M.Sc. (Ag.) in Agricultural Extension / Agricultural Extension and Communication / Agricultural Extension Education / Extension Education
5. Agricultural Microbiology	M.Sc. (Ag.) in Agricultural Microbiology
6. Agronomy	M.Sc. (Ag.) in Agronomy
7. Genetics and Plant Breeding	M.Sc. (Ag.) in Genetics and Plant Breeding
8. 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
9. Plant Molecular Biology and Biotechnology	M.Sc. (Ag.) in Plant Molecular Biology / Agricultural Biotechnology
10. Plant Pathology	M.Sc. (Ag.) in Plant Pathology
11. Seed Science & Technology	M.Sc. (Ag.) in Seed Science & Technology
12. Soil Science and Agricultural Chemistry	M.Sc. (Ag.) in Soil Science and Agricultural. Chemistry

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

4.3.1 The Ph.D. scholars shall report in the Department and sign every day in the attendance register. In order to promote quality research and training in cutting edge areas, the University may permit the scholar to conduct research in recognised universities/research institutes, after the completion of qualifying Viva voce examination.

4.3.2. Project staff/ fellow working in projects in the University, sponsored by Government of India/ Industries / Government of Tamil Nadu can also register.

4.3.3. Candidates in employment should be sponsored by their employer and should avail leave for the minimum duration of the programme and should be formally relieved from their duty to register.

4.3.4. Candidates who are selected under the national level fellowship programmes or by any recognized bodies and who satisfy the eligibility conditions as per the regulations shall apply in the respective discipline.

4.3.5. Admission to Foreign Students: Foreign students, who are selected under various scholarship schemes, either by the Ministry of Education and Culture or by the Ministry of External Affairs, will be given admission on the recommendation / sponsorship of the respective Ministry of Government of India. The other foreign students who seek admission should possess a research VISA issued by the Indian Embassies aboard and produce “No Objection Certificate” from the Ministry of Human Resource Development, Government of India, after clearance from the Ministry of External Affairs. They should also show proof for financial capability for staying, pursuing Ph.D. programme for three years.

5. MODE OF SELECTION

5.1. University shall issue notification for Ph.D. admission once in a year.

5.2. The candidates desirous of registering for Ph.D. programme shall apply by filling all the relevant details mentioned in the online application form posted in the University website

and submit completed application online before the due date as indicated in the notification issued from time to time.

5.3 Incomplete applications and applications with false information in any respect shall be summarily rejected without any intimation to the candidate.

5.4. The Departmental Research Committee (hereafter referred to as DRC) of concerned Department shall screen the applications as per the eligibility norms and shall conduct the written test and interview only for eligible candidates.

5.5. The admission to Ph.D. students shall be based on the following criteria besides general eligibility.

5.5.1 An entrance test at post graduate level for 70 marks (70 multiple choice questions (MCQs), each question carrying one mark and duration of the test is 90 minutes followed by an interview that will have a weightage of 30 marks.

5.5.2 The candidates who secure 50% marks in entrance test and interview put together are eligible for admission.

5.5.3 A relaxation of 5 % marks (from 50 % to 45%) shall be allowed for the candidates belonging to SC/ST/OBC (non creamy layer)/ differentially able category.

5.5.4 Candidates with UGC- JRF / NET / ICAR/ICSSR qualified candidates and teacher fellowship holders are exempted from the Entrance test but they have to appear for the interview and evaluated for 100 marks.

5.6 Departmental Research Committee: The following is the constitution of the DRC. The members other than Head of the Department shall serve only for one academic year.

Designation	**Members**
Head of the Department	Convener
Two professors/ Senior Faculty nominated by the Vice-Chancellor in rotation	Members
One Associate Professor (in rotation)	Member
One Assistant Professor (in rotation)	Member

5.7. The DRC has the following functions

5.7.1 Selection of candidates for admission to the Ph.D. programme.

5.7.2 Facilitating research facilities in the Department.

5.7.3 Maintenance of research quality and quality of publications.

5.7.3 Sorting out any other research related issue of the Department.

5.8. If there is any dispute either in the constitution of functioning of the DRC, it shall be brought to the notice of the Director, DARE and the decision of the Vice-Chancellor shall be final.

5.9. The minutes of the DRC together with the list of selected candidates and their research supervisors along with recommendations of the Dean of the respective faculty will be placed before the Vice-Chancellor for approval.

6. ADMISSION

6.1. The selected candidates shall be issued admission cards and they will be admitted to Ph.D. programme in the respective Department based on his/her PG qualification, entrance and interview.

6.2. The provisional registration order for Ph.D. shall be issued to the candidates.

6.3. The scholar, supervisor, Research Advisor Committee members and examiners shall not be relatives to one another.

7. TUITION FEES AND OTHER FEES

7.1 The selected candidates shall pay the prescribed fees before the last date mentioned in the selection order, failing which they will forfeit the seats.

7.2. The yearly fees shall be paid by the scholars within the prescribed date till the scholar submits the thesis. The supervisors should monitor the regular payment of yearly fees by those scholars who are working under them.

7.3. The registration is liable for cancellation, if the research scholar has not paid the yearly fees within stipulated time.

7.4 Non-payment of yearly fees is a serious lapse on the part of the scholars. Explanation for non-payment of yearly fees shall be called for from the supervisors.

7.5 The various fees payable by the students will be decided by the university from time to time.

7.6 Admission to the hostel will be strictly restricted to the actual accommodation available and no associate will be allowed. A Ph.D. student may be allowed to stay in the hostel for a maximum of five years from the date of admission to the Ph.D. programme.

8. CREDIT GRADE POINT REQUIREMENTS

8.1. A student enrolled for Doctoral program is required to complete 100 credits inclusive of 75 credits of research to become eligible for the degree as detailed below:

Sl. No.	Details	Credit Hours
1	Major Courses	12
2	Minor Courses	6
3	Supporting Courses	5
4	Seminar	2
5	Research	75
	Non credit Compulsory courses	
	Research and Publication Ethics (Contact hours: 2) MOOC (Contact hours: 2)	
	Total	**100**

8.2. In a semester, a Ph.D. scholar can register a maximum of 15 credits excluding research. However, the research credits registered should not exceed 16 per semester. Semester-wise distribution of credits is given in the respective Ph.D. programmes.

8.3. Registration Cards: A student shall register the courses offered in a semester by writing all the courses in registration card in quadruplicate. The Supervisor, Ph.D. Coordinator and Head of the Department are responsible to furnish the registration particulars of the students with their signature in the Registration card to the Dean. The Dean shall approve the registration cards. The approved registration cards shall be maintained by the HoD, Supervisor and the student concerned. The list of courses registered by the students in each semester shall be sent by the Dean to the DARE for preparation of Report Cards.

8.4. The Ph.D. students should complete their course work within the first two semesters in Annamalai University campus.

8.5. Requirements for Ph.D. programme shall also include successful completion of Non-Credit Compulsory Courses, thesis research in the major field of study and submission of thesis thereon.

9. ATTENDANCE REQUIREMENT

9.1 One hundred per cent 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 course whenever offered.

9.2 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.

9.3 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 Research Advisory Committee, HoD and Dean, Faculty of Agriculture on payment of condonation fee prescribed by the university.

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

9.5 In respect of students who had absented for the mid-semester examination (MSE) on university business with prior permission of the HoD and Dean, Faculty of Agriculture, the makeup first test should be conducted ordinarily within 15 working days from the date of conduct of the first test.

9.6 The students who absent himself/herself for first test 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.

10. RESEARCH ADVISORY COMMITTEE

10.1 Each Ph.D. scholar shall have a Research Advisory Committee (RAC) to guide the scholar in carrying out his/her programme.

10.2 A Research Advisory Committee shall be constituted with the approval of the University for each candidate separately, immediately after his/her admission. The purpose of the RAC is to provide expert opinion on frontline research.

10.3 There shall be a Research Advisory Committee for every student consisting of not fewer than four members with the Supervisor as Chairperson. The Research Advisory Committee should have representatives from the major and minor fields. The Research Supervisor should convene a meeting of the Research Advisory Committee at least once in a semester. The research credit evaluation form should be communicated to the Head of Department and the Director, DARE for information.

10.4 Research Supervisor

10.4.1 Every scholar shall have a Research Supervisor (among the recognized guides), who will be appointed by the Vice-Chancellor on the recommendation of the DRC, 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.

10.4.2 A teacher having Ph.D. with 5 years of service and PG teaching is eligible for teaching and guiding Ph. D. scholars. A teacher should have a minimum of three years of service before retirement for allotment of doctoral candidates.

10.4.3 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.

10.5 Functions of the RAC:

10.5.1 Discuss, advice and recommend on all matters connected with the scholar's research from admission till the completion of the programme.

10.5.2 Approve the topic of research and the synopsis.

10.5.3 Assess and approve the progress reports of Ph.D. scholars 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.

10.5.4 If necessary, recommend and approve change of title of dissertation / thesis and change of Research Supervisor.

10.5.5. Conduct the pre-submission presentation (before the submission of synopsis) and to give a certificate to this effect to be submitted along with the synopsis.

10.6 The Research Advisory Committee will meet every semester

10.6.1 To scrutinize the research proposal / progress report submitted by the research scholar.

10.6.2 To assess the conduct of experiments / field work, peruse laboratory notebooks, data recording, analysis, and publication.

10.6.3 To review and endorse the annual progress report of the research scholar.

10.6.4 To approve the synopsis of the thesis.

10.6.4 The Chairperson will convene the Research Advisory Committee meetings with intimation to the Director, DARE through the Head of the Department.

10.7 Changes in RAC

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

10.8 Change of Research Supervisor

10.8.1 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.

10.8.2 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.

10.8.3 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.

10.9 Change of Topic of Research

10.9.1 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 research scholar is relevant to the new research area and the competence of the research supervisor in this field.

10.9.2 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 research scholar will have to go through the process of fresh examination pertaining to the area of research.

10.10 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, DARE in advance.

11. 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.

12. EXAMINATIONS

12.1 There will be two examinations *viz.*, first test and final examination. Wherever the course has practical, there will be a final practical examination also.

12.2 The duration of first test will be of one and half an hour and final examinations in theory and practical will be conducted for three hours each.

12.3 The first test 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, DARE through HOD within seven working days.

12.4 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	First Test	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 first test and final theory examinations are as follows:

First Test (30 marks) (1.5 hours duration)

1	Definitions/concepts	5 out of 7	(5 x 1)	5 marks
2.	Short notes	5 out of 7	(5 x 3)	15 marks
3	Essay type	2 out of 3	(2 x 5)	10 marks

Final Theory: Course without practical (70 marks) (3 hours duration)

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

Final Theory: Course with Practical (40 marks) (3 hours duration)

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

12.3 Minimum Marks for Pass

12.3.1 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 a pass in the subject. 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 upto two decimals.

12.3.2 Students who secure marks below 70 per cent in a subject will be awarded ‘RA’ 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 ‘RA’ grade should appear for re-examination in the subsequent semester. If a student secured ‘E’ grade, he/she has to re-register and attend the course again during the next academic year.

12.4 Minimum GPA Requirement

A Ph. D. student, to continue his/her studies in the University, should maintain certain minimum Average Grade Point prescribed here under:

a) Earn a Grade Point of 7.00 for a pass in each subject.
b) For purpose of continuing as a student in the university, a candidate is required to earn a 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.

12.5 Re-Examination

12.5.1 Re-examination is permitted only for the final theory and practical examinations. The students who secure ‘RA’ grade are permitted to write the re-examinations as and when conducted with the permission of university.

12.5.2 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.

12.5.3 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 first test will be retained and the student should produce the practical record during re-examination. The registration for the re-examination shall be done after first test on the date specified by the Director, DARE. Each registration is considered as an attempt even if the student absents for the examination.

12.6 Return of Valued Answer Papers

12.6.1 The valued answer papers of first test 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.

12.6.2 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, DARE after the conduct of examination and then disposed off.

13. 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.

13.1 Seminar Topic

13.1.1 The seminar topic should be only from the major field and should not be related to the area of thesis research. The seminar topics are to be assigned to the students by the Research

Supervisor in consultation with HOD within three weeks after commencement of the semester.

13.1.2 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.

13.1.3 The circular on the presentation of the seminars may be sent to other Departments to enable those interested to attend the same. The Research Supervisor will monitor the progress of the preparation of the seminar and correct the manuscript.

13.1.4 The student will submit two copies of the corrected manuscript to the HOD through Research Supervisor 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.

13.1.5 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**

14. QUALIFYING EXAMINATION

Only those students who successfully complete the qualifying examination will be admitted to candidacy of the degree. The qualifying examination consists of only Viva-voce examination.

14.1 Minimum requirement for qualifying Viva-voce 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 successful completion of course work.

14.2 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, DARE. One of them will be appointed as external examiner.

14.3 Qualifying Viva-Voce Examination

14.3.1 The evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic.

14.3.2 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.

14.3.3 The Head of the Department will monitor and coordinate the conduct of the qualifying viva. The performance of the candidate will be graded as Satisfactory / Unsatisfactory.

14.4 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 Director, DARE through HOD in the prescribed format.

14.5 Failure /Absence in Qualifying Examination

14.5.1 When a student fails or absents for the qualifying examination, he/she may apply again for permission to appear for re-examination to the Director, DARE with the recommendation of the RAC and Head of the Department.

14.5.2 A student, who applies for re-examination should attend viva-voce. Re-examination shall not take place earlier than one month after the first examination. It will be conducted by the RAC as previously indicated.

14.5.3 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 student fails in the qualifying examination, he/she is not permitted to register for further research credits in the next semester.

15. THESIS RESEARCH

15.1 Selection of Topic

15.1.1 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.

15.1.2 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

15.2 Research Proposal

15.2.1 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.

15.2.2 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 faculties of the Department for improving it. Three copies of the research proposal in the prescribed format should be sent to the Director (DARE) through the Head of the Department for approval.

15.2.3 The distribution of research credit will be as follows:

Semester	Credit Hours
I Semester	0+2
II Semester	0+10
III Semester	0+16
IV Semester	0+16

V Semester	0+16
VI Semester	0+15
Total	**0+75**

15.3 Evaluation of Thesis Research

15.3.1 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 research programme has to be given to the student for carrying out the work during that semester.

15.3.2 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.

15.3.3 The student has to submit his/her research observation note book to the Research Supervisor, who will scrutinize the progress and sign the note book with remarks as frequently as possible. This note book will form the basis for evaluation of research progress.

15.3.4 After completion of 80% attendance for research and on or before the last day of the semester, the research scholars, shall submit Progress Reports in the prescribed format duly endorsed by the Research Advisory Committee to the Director, DARE until they submit their synopsis.

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

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

15.3.7 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.

15.3.8 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 per cent 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 re-registered 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,

- Failure of crop
- Non-incidence of pests or disease or lack of such necessary experimental conditions.
- Non-availability of treatment materials like planting materials chemicals, etc.
- Any other impeding / unfavorable 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 fails 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 the University based on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

16. SUBMISSION OF THESIS

16.1 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.

16.2 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.

16.3 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 ensuing year.

16.4 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 Department 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.

16.5 Three 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.

16.6 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, DARE through the HOD and the Dean. A soft copy of the thesis in PDF format as prescribed by Shodhganga, shall also be submitted.

16.7 The Ph.D. scholars have to publish a minimum of two research papers in NAAS rated journals with 5 and above rating/ Scopus / Web of Science indexed journals at the time of publication of the papers. The synopsis will be accepted for processing only after showing evidences for publications of two such research papers.

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

16.9 Pre-submission Presentation

16.9.1 The pre-submission presentation of the thesis is a requirement to enrich the scholar and to fine tune his/her research presentation. This presentation shall be conducted before the submission of the synopsis in the presence of the RAC, Supervisor/Co-Supervisor, HoD, Faculty members, Research Scholars and/or P.G. Students.

16.9.2 The scholar shall present the findings. The gathering may suggest ideas / references to be consulted / suggestions to improve the work.

16.9.3 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, DARE.

16.10 Submission of Synopsis

16.10.1 The submission of synopsis may be permitted 3 months before the completion of required duration on successful completion of course work.

16.10.2 The Research Scholar shall submit 3 copies of the synopsis approved by the Research Advisory Committee along with a soft copy to the Director, DARE through the Research Supervisor, the HOD and Dean of the respective Faculty.

16.10.3 Guidelines for the preparation of the synopsis are appended in Appendix I. 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 Appendix III.

16.11 Guidelines for Preparation of Thesis

16.11.1 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.

16.11.2 The specification for the preparation of the thesis is given in Appendix II. A model cover page for a thesis is given in Appendix IV.

16.11.3 The thesis shall be typed on both sides of the page in order to save paper and postage. The thesis shall contain a Certificate from the guide (Annexure) 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, Associate ship, Fellowship or similar title.

16.11.4 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. (Appendix V)

16. VALUATION OF THE THESIS

17.1 Panel of Examiners

17.1.1 The thesis submitted in partial fulfilment 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.

17.1.2 The external experts 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.

17.1.3 The external experts shall send their evaluation reports on the thesis directly to the Director, DARE along with the copy of the evaluated thesis. The Director, DARE on receipt of the reports from the two examiners will send them to the concerned Research Supervisor who is the convener of viva-voce board.

17.1.4 The Research Supervisor will send the consolidated report with his remarks to the Director, DARE through the Head of the Department. Based on the satisfactory reports of the evaluation, Viva-voce examination will be arranged.

17.1.5 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 the final Viva-voce examination.

17.1.6 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.

17.1.7 The candidate is expected to defend the thesis at the Viva-voce examination. The degree shall be awarded on the unanimous recommendation of the Viva-Voce board as **satisfactory** with regard to the thesis and the performance of the student in the final Viva-voce examination.

17.1.8 The recommendation of the Viva-Voce board shall be forwarded to the Director, DARE by the Research Supervisor through HOD and Dean which shall be signed by all members of the committee and the external examiner.

17.1.9 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

17.2 Revision and Resubmission of Thesis

17.2.1 If an examiner recommends change / further work, the thesis will be referred to the same examiner after compliance for his/her 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.

17.2.2 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.

17.3 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 three years.

17.4 Extension of Time

17.4.1 Research scholars who do not submit the thesis within the stipulated period should apply for extension of time three months before the completion of three 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 three years.

17.4.2 The scholar will have to enrol as fresh candidates if he/she fails to submit the thesis within the maximum extension period of three years when granted.

17.4.3 If a scholar requires a few more months after the expiry of the maximum extension period of three 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.

17.5.1 Number of Chances

17.5.1 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.

17.5.2 Also, he / she will not be permitted to appear for the viva-voce examination on more than two occasions.

18. DISCONTINUANCE AND READMISSION

18.1 Students admitted to the Ph.D. degree who discontinue 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.

18.2 After completion of course work and qualifying examination, a student is eligible to discontinue temporarily his research program only once within 5 years for Ph. D. program. If the discontinuation period exceeds two semesters, the student has to forego the research credits already registered and register afresh with revised program.

18.3 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.

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

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GENT 81 – Ph.D. in GENETICS AND PLANT BREEDING

PROGRAMME OUTCOME

PO 1	Genetic architecture of crop plants is mandatory before starting any successful programme in crop improvement through gene manipulation. The graduates could manipulate different breeding methods by harnessing pollination mechanism
PO 2	The scholars specialized in genetics and plant breeding will be able to conduct independent research trial which will be immense useful in harnessing genetic improvement programme.
PO 3	Moreover geneticists cum plant breeders are effectively observed by agricultural scientific recruitment board and State Agricultural Universities including affiliated agriculture colleges at various capacities. essential for carrying out cutting edge research
PO 4	The graduate could augment food production and achieve food and nutritional security by the way of enhancing the productivity under changing climatic scenario.
PO 5	The graduates will gain accurate and relevant analytical skills in problems and will have capacity to interpret the information, analyse research data and draw appropriate statistical conclusion and adapt to changing situation to understand theoretical standard.

PO and CO Mapping Matrix

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

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

SEMESTER WISE DISTRIBUTION OF CREDIT

Semester	Major Course	Minor Course	Supporting Course	Seminar	Research	Total credit	Non credit Compulsory course
I	6	4	2	1	2	**15**	-
II	6	2	3	1	10	**22**	-
III	-	-	-	-	16	**16**	Research and Public Ethics
IV	-	-	-	-	16	**16**	**MOOC**
V	-	-	-	-	16	**16**	-
VI	-	-	-	-	15	**15**	-
Total credit	**12**	**6**	**5**	**2**	**75**	**100**	-

Course code	Course Title	Credit hour (Theory + Practical)
	Major Courses (Any 5 out of 8 major courses)	12
GPB 601#	Advances in Plant Breeding Systems	3(3+0)
GPB 602	Advances in Biometrical Genetics	3(2+1)
GPB 604	Plant Genetics Resources, Conservation and Utilization	2(2+0)
GPB 605#	Genomics in Plant Breeding	3(3+0)
GPB 607	Crop Evolution	3(3+0)
GPB 609#	IPR and Regulatory Mechanism (e-course)	1(1+0)
GPB 610	Hybrid Seed Production Technology	3 (2+1)
GPB 613	Seed Vigour and Crop Productivity	2 (1+1)
	# Compulsory Course	
	Minor Course (Any 3 out of 5 minor courses)	6
GPB 603	Molecular Cytogenetics for Crop Improvement	2(2+0)
GPB 606	Population Genetics	2(2+0)
GPB 608	Breeding Designer Crops	2(1+1)
GPB 611	Commercial Plant Tissue Culture	2(2+0)
GPB 612	Plant Hormones and Signalling	2(2+0)
	Supporting Courses	5
COM 601	Advances in Computer Applications(1+1)	2
STA 601	Advances in Designs of Experiments (2+1)	3
	Seminar	
	Doctoral Seminar – I (0+1)	1
	Doctoral Seminar – II (0+1)	1
	Research	
	Doctoral Research (0+75)	75
	Non credit compulsory courses	
	MOOC (2+0)	-
	Research and Public Ethics (2+0)	-

Semester wise Distribution of Courses

Sl. No	Courses	Credit Hours
I	**First Semester**	
1	**Major Courses**	6
2	**Minor courses**	4
3	COM 601 Advances in Computer Application	1+1
4	AEC691 Seminar	0+1
5	AEC 699 Research	0+2
	Total credits	
II	**Second Semester**	
1	**Major Courses**	6
2	Minor courses	2
3	STA 601 Advances in Designs of Experiments	2+1
4	AEC 692 Seminar	0+1
5	AEC 699 Research	0+10
	Total credits	
III	**Third Semester**	
1	Research and Public Ethics*	2+0
2	AEC 699 Research	**0+15**
IV	**Fourth Semester**	
1	MOOC*	2+0
2	AEC 699 Research	**0+16**
V	**Fifth Semester**	
1	AEC 699 Research	**0+16**
VI	**Sixth Semester**	
1	AEC 699 Research	**0+16**
	Grand total	**100**

GPB 601 - ADVANCES IN PLANT BREEDING SYSTEMS - (3+0)

Learning objectives

- To impart theoretical knowledge about advances in plant breeding.
- To impart theoretical knowledge about various plant breeding methodologies and procedures
- To impart theoretical knowledge about MAS
- To impart theoretical knowledge about Gene pyramiding.
- To impart theoretical knowledge about marker-based utilization of exotic Germplasm and introgression libraries

Theory

Unit I: Advances in reproductive biology of crops

Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer. Plant Breeding methodologies: Classic versus modern; Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

Unit II: Population improvement

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities. Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

Unit III: Self incompatibilty and male sterility

Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and biochemical basis of self-incompatibility and male sterility, nucleo cytoplasmic interactions with special reference to male sterility – genetic, biochemical and molecular bases.

Unit IV: Genetic engineering

Genetic engineering technologies to create male sterility, prospects and problems, use of self-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies - Generating new cyto-nuclear interaction system for diversification of male sterile; Stability of male sterile lines – Environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding; Apomixis and its use in heterosis breeding; Incongruity:
Factors influencing incongruity Methods to overcome incongruity mechanisms.

Unit V: Stress breeding

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation,; Breeding for bio-fortification.

Lesson plan

Theory lecture schedule

1. Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed
2. Pollen pistil interaction: biochemical and molecular basis
3. Environmental factors governing anthesis and bottlenecks for gene transfer
4. Plant Breeding methodologies: Classic versus modern
5. Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops
6. Molecular and transgenic breeding approaches; doubled haploid breeding
7. Shuttle breeding
8. Forward and reverse breeding
9. speed breeding
10. Participatory plant breeding
11. Breeding for organic situations.
12. Principles and procedures in the formation of a complex population
13. Genetic basis of population improvement in crop plants
14. Recurrent selection methods in self and cross pollinated crops and their modifications
15. Convergent selection, divergent selection
16. Recurrent selection, usefulness in hybrid breeding programs
17. Reciprocal recurrent selection
18. Selection in clonally propagated crops
19. Choice of molecular markers for plant breeding efficiency
20. Fingerprinting and genetic diversity assessment
21. Application of MAS for selection of qualitative and quantitative traits
22. Gene pyramiding
23. Accelerated backcrossing
24. Marker-based utilization of exotic germplasm
25. **First test**
26. Introgression libraries
27. Genetic resources: primary, secondary, tertiary and alien trans gene pool
28. self-incompatibility
29. Molecular and biochemical basis of self-incompatibility
30. Molecular and biochemical basis of male sterility
31. Nucleocytoplasmic interactions with special reference to male sterility
32. Genetic engineering technologies to create male sterility, prospects and problems
33. use of self-incompatibility and sterility in plant breeding
34. Fertility restoration in male sterile lines and restorer diversification programs
35. Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies
36. Generating new cyto-nuclear interaction system for diversification of male sterile
37. Stability of male sterile lines
38. Environmental influence on sterility
39. Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies
40. Photo sensitive genetic male sterility and its use in heterosis breeding;
41. Thermo sensitive genetic male sterility and its use in heterosis breeding;
42. Temperature sensitive genetic male sterility and its use heterosis breeding
43. Apomixis and its use in heterosis breeding
44. Incongruity
45. Factors influencing incongruity Methods to overcome incongruity mechanisms
46. Breeding for climate change

47. Improving root systems, abiotic stress tolerance
48. Water use efficiency - flooding and sub-mergence tolerance; Biotic stress tolerance
49. Nutrient use efficiency, nitrogen fixation and assimilation
50. Greenhouse gases and carbon sequestration, Nitrogen fixation and assimilation

Course outcome

CO 1: After completion of this course the student will be able to know various plant breeding methodologies
CO 2: Principles and procedures for the formation of a complex population;
CO 3: MAS for selection of qualitative and quantitative traits
CO 4: Gene pyramiding,
CO 5: Marker based utilization of exotic Germplasm and Breeding for climate change

CO PO - Mapping matrix

	PO 1	PO2	PO3	PO4	PO5
CO1	2	-	-	2	2
CO2	-	1	-	-	1
CO3	3	-	-	2	2
CO4	1	-	2	2	-
CO5	2	2	3	-	-

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2. Allard RW. 1966. Principles of Plant Breeding. John Wiley & Sons.
3. Briggs FN and Knowles PF. 1967. Introduction to Plant Breeding. Reinhold.
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GPB 602 - ADVANCES IN BIOMETRICAL GENETICS - (2+1)

Learning objectives:

- To inculcate theoretical knowledge and computation skills pertinent quantitative traits.
- To ingress knowledge on partitioning of different allelic and non allelic interactions.
- To impart theoretical knowledge and computation skills regarding mating designs and gene effects.
- Basic understanding on the application aspects of genetics analysis and their significance in plant breeding.

- To instigate the importance of molecular marker based analysis and its utilization in mapping QTL's.

Theory

Unit I: Qualitative and quantitative techniques

Continuous variation-evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques - differences, population types, approaches; various types of metrics, F_2, F∞ and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.

Unit II: Gene action

Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase; Epistasis- Specification, weighted and un-weighted joint scaling test; Effect of linkage to generation mean, specification of mean to G × E interaction.

Unit III: Components of variance

Component of variances-advantages, variances of different generations, balance sheet of variance; estimation of parameters-weighted and unweighted, least square analysis; random mating population; experimental population-BIPs, NCD-I, II, III, Triple test cross for random mating population and inbreds; Estimates of linkage and non-allelic interactions; Combining ability analysis, Hayman's Approach.

Unit IV: Stability analysis

G × E Interaction, stability and adaptability; Advanced models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.

Unit V: QTL Mapping

Construction of saturated linkage maps, concept of framework map development; QTLs-different types of markers and mapping populations, linkage maps, mapping- Strategies for QTL mapping - desired populations, statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretation of analysed data.

Practicals

Generation mean analysis: ABC scaling test and Joint scaling test- Analysis and interpretation; Estimation of variance of different filial generations and interpretations; Diallel analysis: Numerical, graphical and combining ability analysis; Triallel analysis; NCD - Designs: Triple test cross analysis; Stability analysis: Eberhart and Russel model; AMMI model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes; Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies; Use of advanced software in biometrical analysis.

Lesson plan

Theory lecture schedule

1. Continuous variation – Dis continuous variation evolutionary studies.
2. Genetic principles of continuous variation.

3. Qualitative and quantitative techniques – differences.
4. Population types, approaches.
5. Various types of metrics, F_2, F∞ and mixed populations.
6. Selection of parents Simultaneous selection models.
7. Use of Multiple regression analysis in selection of genotypes.
8. Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance.
9. Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase.
10. Epistasis- Specification, weighted and un-weighted joint scaling test.
11. Effect of linkage to generation mean, specification of mean to G × E interaction.
12. Component of variances-advantages, variances of different generations, balance sheet of variance.
13. Estimation of parameters-weighted and unweighted, least square analysis; random mating population.
14. Estimation of parameters - experimental population-BIPs, NCD-I, II, III.
15. Experimental population - Triple test cross for random mating population and inbreds.
16. Estimates of linkage and non-allelic interactions.
17. **First test**
18. Combining ability analysis, Hayman's Approach.
19. G × E Interaction, stability and adaptability; Advanced models in stability analysis.
20. Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models
21. Merits and limitation of different stability analysis methods.
22. Analysis and selection of genotypes; Methods and steps to select the best model –
23. Biplots and mapping genotypes.
24. Construction of saturated linkage maps, concept of framework map development.
25. QTLs-different types of markers and mapping populations, linkage maps, mapping.
26. Strategies for QTL mapping - desired populations, statistical methods.
27. MAGIC populations.
28. Marker Assisted Selection (MAS)
29. Approaches to apply MAS in Plant breeding
30. Selection based on markers - simultaneous selection based on marker and phenotype
31. Factors influencing MAS.
32. Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods
33. Use of advanced software packages for biometrical analysis,
34. Interpretation of analysed data.

Practical schedule

1. Generation mean analysis
2. ABC scaling test and Joint scaling test- Analysis and interpretation
3. Estimation of variance of different filial generations and interpretations
4. Diallel analysis - Numerical analysis
5. Diallel analysis - Graphical and combining ability analysis
6. Triallel analysis
7. NCD –Designs
8. Triple test cross analysis and interpretations
9. Stability analysis

10. Eberhart and Russel model - interpretaitons
11. AMMI model
12. Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model –
13. Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes
14. Construction of linkage maps and QTL mapping - Strategies for QTL mapping
15. Statistical methods in QTL mapping
16. Phenotype and Marker linkage studies
17. Use of advanced software in biometrical analysis.

Course outcomes:

CO 1: To understand various Qualitative and Quantitative techniques.
CO2: Analyze and evaluate literature involving quantitative genetic experiments.
CO 3: Design and analyze quantitative genetic experiments.
CO4: Statistically analyze the phenotypic data of plant traits collected taking into account G X E interaction, Construction of saturated linkage maps and Marker Assisted Selection.
CO5: Use of advanced software packages for biometrical analysis, interpretation of analyzed data.

CO-PO Mapping matrix

	PO 1	PO2	PO3	PO4	PO5
CO1	3	2		3	
CO2	2			3	
CO3	2		2	3	2
CO4	2			3	
CO5	2			3	

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1. Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.
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GPB 603 - MOLECULAR CYTOGENETICS FOR CROP IMPROVEMENT - (2+0)

Learning objectives

- To understand organization and structure of genome for crop improvement
- To understand organization and structure of karyotyping for crop improvement
- To understand Pre-breeding methods for crop improvement
- To understand role of polyploidy for crop improvement
- To impart knowledge on applications of cytogenetic techniques for crop improvement

Unit I: Structure of genome

Organization and structure of genome, Genome size, Organization of organellar genomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions and signal transduction; Inheritance and expression of organellar DNA; Variation in DNA content - C value paradox; Sequence complexity – Introns and Exons, Repetitive sequences, Role of repetitive sequence.

Unit II: Karyotype

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/ genomic segments.

Unit III: Pre-breeding methods

Pre-breeding and applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-usein producing inbreds, transfer of genes- linked marker methods; Duplication - production and use; Inversions and location of genes; B/ A chromosome translocations and gene location.

Unit IV: Trisomics

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics methods of production, breeding behavior and location of genes; Intervarietal substitutions-allelic and non-allelic interactions; Telocentric method of mapping.

Unit V: Cytogenomics and polyploidy

Cytogenomics: Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location. Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distant hybridization, barriers to interspecific and intergeneric hybridization; Behaviour of interspecific and intergeneric crosses.

Lesson plan

Theory lecture schedule

1. Organization, Structure and size of genomes.
2. Organellar DNA Organization.
3. Nuclear DNA Organization.
4. Nuclear X Cytoplasm interactions and signal transduction.
5. Transmission genetics of organellar genes.
6. Transcription and translation by
7. DNA Content – Variation and 'C' Value Parador.
8. Sequence Complexity – Gene Splicing – repetitive sequences.
9. Karyotyping – Chromosome banding
10. Karyotyping – Chromosome Painting
11. Gene Introgression using Fish and Gish.
12. Cocalization and mapping of gores.
13. Pre – breeding techniques.
14. Applications of cytogenetical methods of for crop improvement.
15. Location and mapping of genes on Chromosomes.
16. Chromosome deficiency – Genetic Consequensces.
17. **First test**
18. Balanced Lethal System – Maintenance and Utility - Multiple interchanges – production of inbreeds.
19. Gene transfer methods – linked marker method.
20. Gene duplications – production and Use
21. Inversion and location of genes.
22. Gene translocation and location of genes.
23. Trisomics – types and production.
24. Breeding behavior of transonic and location of genes.
25. Trisomics and hybrid seed production.
26. Monosomics – types and production.
27. Breeding behavior of monosomics and location of genes.
28. Gene Substitution and non-allelic interactions.
29. Telocentric method of mapping.
30. Cytogenomics – Concept and its sole in crop improvement program me.
31. Chromosome sorting, Development of molecular maps and gene location.
32. Role of Polyploidy in Crop evolution and breeding.
33. Auto – and allopolyploids – Man made crops.
34. Barriers to interspecfic/intergenetic hybridization and breeding behavior of distant hybrids.

Course outcome

Co 1.Understanding organization and structure of genome for crop improvement

CO 2. Understanding organization and structure of karyotyping for crop improvement

CO 3. Understanding Pre-breeding methods for crop improvement

CO 4. Understanding role of polyploidy for crop improvement

CO5. Imparting knowledge on applications of cytogenetic techniques for crop improvement

CO-PO Mapping matrix

	PO 1	PO2	PO3	PO4	PO5
CO1	3	2		3	
CO2	2			3	

CO3	2		2	3	2
CO4	2			3	
CO5	2			3	

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GPB 604. PLANT GENETIC RESOURCES, CONSERVATION AND UTILIZATION (2+0)

Learning objectives

- To infuse the students about the means and ways of germplasm collection
- To make the students to understand the importance of germplasm conservation
- To explore various technical know-how's involved in the preservation of germplasm
- To have an insight into the activities carried out by NBPGR
- To sort out the challenges ahead in the conservation of perennial crops

Theory

Unit I

Concept of natural reserves and natural gene banks; *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

Unit II

Ex situ conservation: components, plant genetic resources conservation in gene

banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and eXchange to network of active/ working collections, orthodoX, recalcitrant seeds- differences inhandling, clonal repositories, genetic stability under long term storage condition.

Unit III

In-vitro storage, maintenance of *in-vitro* culture under different conditions, *in-vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in-vitro* gene bank.

Unit IV

Cryopreservation- procedure for handling seeds of orthodoX and recalcitrant- cryo-protectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/ dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

Unit V

Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and mini core; collections and registration of plant germplasm.

Lesson plan

Theory lecture schedule

1. Concept of natural reserves and natural gene banks;
2. *In situ* conservation of wild species in nature reserves
3. *in situ* conservation components, factors influencing conservation value
4. National plan for *in situ* conservation
5. *in situ* conservation of agro-biodiversity on-farm
6. scientific basis of *in situ* conservation
7. implementation of on-farm conservation
8. management of *in situ* conserved genetic diversity on-farm
9. enhancing benefits forfarmers from local crop diversity.
10. *Ex situ* conservation: components, plant genetic resources conservation in gene banks
11. Preservation of genetic materials under natural conditions
12. Perma-frost conservation
13. guidelines for seed multiplication and eXchange to network of active and working collections
14. OrthodoX, recalcitrant seeds- differencesinhandling
15. Clonal repositories, Genetic stability under long term storage condition.
16. *In-vitro* storage, maintenance of *in-vitro* culture under different conditions
17. **First Test**
18. *in-vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species
19. Conservation of embryos and ovules, cell/ suspension cultures
20. Protoplast and callus cultures, pollen culture
21. Micropropagation techniques,
22. Problems, prospects of *in-vitro* gene bank.
23. Cryopreservation- procedure for handling seeds of orthodoX
24. Cryopreservation- procedure for handling seeds of recalcitrant

25. Cryo-protectants, desiccation, rapid freezing, slow freezing, vitrification techniques,
26. Encapsulation/ dehydration techniques, national facilities, achievements,
27. Applicationof cryopreservation in agricultural, horticultural and forestry crops.
28. Problems and prospects in Cryo-Preservation
29. Challenges ahead in cryopreservation
30. Concept and procedure for PGR management
31. Germplasm characterization
32. Evaluation and utilization of Germplasm
33. Concept of core and mini core; collections
34. Registration of plant germplasm

Course outcome

CO 1. Students will be explored to delineate the various techniques of germplasm conservation.
CO 2. Importance of Expedition will be exercised by the students
CO 3. Concept of core and mini-core collection will be understood
CO 4.The necessity to register the collected germplsam and various intricacies registration is well elucidated.
CO 5. To explore the students to figure out various activities undertaken by NBPGR

CO-PO Mapping matrix

	PO 1	PO2	PO3	PO4	PO5
CO1	-	-	-	-	-
CO2	-	**1**	**2**	-	-
CO3	-	-	-	3	-
CO4	-	-	-	-	**4**
CO5	-	-	**5**	-	-

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GPB 605 - GENOMICS IN PLANT BREEDING - (3+0)

Learning objectives :

- To impart knowledge of recent trends in plant genomics, genome sequencing.
- To impart knowledge about the concepts of high – throughput proteomics, metabolomics and phenomics in crop improvement programmes.
- To impart practical skills in advanced molecular techniques in genome mapping, structural/functional genomics.
- To gain knowledge about bioinformatics.
- To know about the genome editing tools.

Theory

UNIT I : Introduction to the plant genomes

Introduction to the plant genomes : nuclear, chloroplast and mitochondrial genomes ; Concept of genome size and complexity : C- value paradox, repetitive and unique DNA.Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ligation and single molecule real time (SRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

UNIT II : Molecular maps

Molecular maps : Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/ QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology; Concepts and applications.

UNIT III : Functional genomics

Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT – PCR and molecular beacon.

UNIT IV : Bio informatics

Development and management of database; Applications of bioinformatics tools/ softwares in genomics for crop improvement. Basic concepts of high – throughput proteomics, metabolomics and phenomics.

UNIT V : Marker assisted selection

Recent transgene free genome editing tools such as CRISPR- Cas9 system, TALENS and ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sisters for crop improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single genes and QTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).

Lesson plan

Theory lecture schedule

1. Introduction to plant genome.
2. Molecular description of plant nuclear genomes.
3. Chloroplast genome and Mitochondrial genome.
4. Genome size and complexity.
5. Plant genome sequencing – principles & techniques.
6. Next generation sequencing - sequencing-by-synthesis/ligation and single molecule real time (SRT) technologies.
7. Application of sequence information in plant genome analyses.
8. Plant genome projects - shot gun and clone-by-clone method.
9. Genome mapping.
10. Molecular markers – Introduction.
11. Recent strides in molecular markers.
12. Strategies for mapping genes in plants.
13. Linkage and LD- basaed gene mapping approaches -Mapping agronomic traits and QTL : GWAS and association analysis.
14. Map based cloning of plant geness.
15. Concepts of Allele mining.
16. Concepts and application of Diversity array technology.
17. **First test**
18. Functional genomics – concept of reverse and forward genetics.
19. Activation tagging, Transposon tagging, Insertional mutagenesis.
20. TILLING and ecoTILLING – crop improvement.
21. Genome-wide and gene specific transcriptomics-approaches: serial analysis , massively parallel signature sequencing, next generation sequencing.
22. Microarray, Northern hybridization.
23. RT-PCR, qRT – PCR and molecular beacon.
24. Development and management of database.
25. Bioinformatics tools/ softwares – Applications in crop improvement.
26. Basic concepts of high – throughput proteomics.
27. Basic concepts – metabolomics and phenomics.
28. Transgene free genome editing tools – CRISPR Cas9 system, TALENS and ZFNs – role in crop improvement.
29. Cisgenesis and Intragenesis tools – twin sisters for crop improvement.
30. Genomics – based plant breeding : Genome – Wide Genetic Diversity Studies.
31. Identification of molecular markers linked to single genes and QTL.
32. Marker Assisted Selection – Marker Assisted Backcross Selection, Association mapping.
33. Association mapping
34. Marker Assisted Selection – Breeding by Design, Genome selection.

Course outcome

CO 1 : Student will gain knowledge about techniques for genome sequencing.

CO 2 : Better understanding about molecular maps.

CO 3 : Knowledge on concepts of high – throughput proteomics, Bioinformatics
CO 4 : Importance of metabolomics and phenomics in crop improvement.

CO - PO Mapping matrix

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

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GPB 606 - POPULATION GENETICS - (2+0)

Learning objectives

- To make the students aware about the population genetics.
- To impart knowledge on structure, properties and breeding values of different populations.
- To impart knowledge on Hardy-Weinberg equilibrium.
- To know about the mating frequencies.
- To learn the components and applications in crop improvement.

Theory

UNIT - I. Properties of population

Population: Properties of population, Mendelian population; Genetic constitution of a population through time, space, age structure, etc.; Frequencies of genes and genotypes; Causes of change: population size, differences in fertility and viability, migration and mutation.

UNIT - II. Hardy - Weinberg law and applications

Hardy-Weinberg equilibrium, Hardy-Weinberg law, Proof and applications of the Hardy-Weinberg law, Test of Hardy-Weinberg equilibrium; Mating frequencies: Non-dominance, Codominance, Snyder's ratio, importance and its effect over random mating in succeeding generations.

UNIT - III. Factors disturbing the population

Multiple alleles, More than one locus, Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency, Migration, Mutation, Recurrent and non-recurrent Selection; Balance between selection and mutation; Selection favouring heterozygotes; Overdominance for fitness.

UNIT - IV. Mating systems

Mating systems, Random mating population, Nonrandom mating: selfing –inbreeding coefficient, panmictic index, sibmating, Assortative mating and disassortative mating; Pedigree populations and close inbreeding, Estimation of linkage disequilibrium, Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops; Gene substitution and average effects;

UNIT - V. Breeding value

Breeding value - Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis - Adaptive organization of gene pools; Polymorphism - Balanced and Non-balanced polymorphism, heterozygous advantage - Survival of recessive and deleterious alleles in populations.

Lesson plan

Theory lecture schedule

1. Population: Properties of population, Mendelian population
2. Genetic constitution of a population through time, space, age structure, etc.,
3. Frequencies of genes and genotypes
4. Causes of charge: Population size, differences in fertility and viability, migration and mutation
5. Hardy – Weinberg equilibrium
6. Hardy – Weinberg law, Proof and applications of the Hardy – Weinberg law
7. Test of Hardy – Weinberg equilibrium
8. Mating frequencies
9. Non-dominance, Codominance, Synder's ratio, importance and its effect over random mating in succeeding generations
10. Multiple alleles
11. More than one locus
12. Sex linked genes
13. Use of gene and genotypic frequencies evaluation in field population level
14. Interpretations
15. Changes of gene frequency, migration, mutation
16. Recurrent and non-recurrent selection
17. **First test**
18. Balance between selection and mutation
19. Selection favoring heterozygotes
20. Over dominance for fitness

21. Mating systems
22. Random mating population
23. Non-random mating: selfing – inbreeding coefficeint, panmictic index, sibmating, assortative mating and disassortative mating
24. Pedigree populations and close inbreeding
25. Estimation of linkage disequilibrium
26. Correlation between relatives and estimation of F
27. Effect of inbreeding and sibbing in cross pollinated crops
28. Gene substitution and average effects
29. Breeding value – Genetic drift;
30. Genetic slippage, co-adapted gene complexes;
31. Homoeostasis – Adaptive organization of gene pools
32. Polymorphism – Balanced and Non-balanced polymorphism
33. Heterozygous advantage
34. Survival of recessive and deleterious alleles in populations.

Course outcome

CO 1.To obtain knowledge on applications of population genetics.
CO 2.To acquire knowledge about different mating designs.
CO 3.To know about Hardy-Weinberg law.
CO 4.To acquire knowledge about factors influencing population genetics.
CO 5.To know about the importance of different genetic parameters in crop improvement.

CO - PO Mapping matrix

	PO1	PO2	PO3	PO4	PO5
CO1		**1**			**2**
CO2	**2**	**1**			**3**
CO3		**1**			
CO4		**1**			
CO5		**1**		**2**	

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GPB 607 - CROP EVOLUTION - (3+0)

Learning objectives

- To impart knowledge on crop evolutionary aspects of crop species.
- To impart knowledge about the origin and centers of diversity, speciation, domestication.
- To provide deep knowledge on significance of polyploidy.
- To impart knowledge on role of mutations
- To impart knowledge and practical skills on hybridizations and polyploidy in crop evolution.

Theory

Unit I: Origin and domestication

Origin and evolution of species; Centers of diversity/origin, diffused centers; Time and place of domestication; Patterns of evolution and domestication - eXamples and Case studies; Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift – Consequences.

Unit II: Hybridization and speciation

Speciation and domestication – The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization-speciation and eXtinction; EXploitation of natural variation: Early attempts to increase variation, Distant hybridization and introgression, Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their eXpression; Controlled introgressions.

Unit III: Genome organization

Genome organization – Transgenesis in crop evolution, Multi factorial genome, Intra genomic interaction, Inter genomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.

Unit IV: Evolution of polyploidy and Manipulation

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of auto-polyploids; haploidy and DH-method of production and use of allo-polyploids;

Unit V: Synthesis of new crops

Polyploids: Synthesis of new crops**;** Case studies – Cereals, Pulses, Oilseeds, vegetables, Fibre crops, Plantation crops, Forage crops, Tuber crops, Medicinal Plants.

Lession plan

Theory

1. Introduction to Origin and evolution of species
2. Centres of diversity/origin – diffused centres
3. Time and place of domestication
4. Patterns of evolution
5. Domestication – eXamples and Case studies
6. Domestication and uniformity
7. Characteristics of early domestication and changes
8. Concept of gene pools and crop evolution
9. Selection - Consequences
10. Genetic drift–Consequences
11. Introduction to Speciation and domestication
12. The process of speciation and Reproductive isolation barriers

13. Genetic differentiation during speciation
14. Hybridization-speciation and extinction
15. Exploitation of natural variation
16. Early attempts to increase variation
17. Distant hybridization and introgression
18. Inter-specific, inter-generic hybridization, scope and limitations
19. Techniques to overcome the limitations
20. Gene transfer into cultivated species, tools and techniques
21. Validation of transferred genes and their expression
22. Controlled introgressions
23. Introduction to Genome organization
24. Transgenesis in crop evolution
25. Multi factorial genome, Intra- genomic interaction, Inter- genomic interaction
26. **First test**
27. Genome introgression
28. Methods to study crop evolution - Contemporary Methods
29. Based on morphological features
30. Cytogenetic analysis, Allozyme variations and crop evolution
31. DNAmarkers
32. Genome analysis
33. Comparative genomics.
34. Processes in crop evolution and stabilization of polyploids
35. Cytogenetic and Genetic stabilization
36. Evolutionary significance of polyploidy
37. Evolution of crop plants through ploidy manipulations
38. Introduction to polyploidy
39. Auto-polyploids and its significance
40. Production of haploid and doubled haploids
41. Allo-polyploids and its significance
42. Polyploids: synthesis of new crops- Introduction
43. Case studies: Cereals
44. Case studies: Pulses
45. Case studies: Oilseeds
46. Case studies: vegetables
47. Case studies: Fibrecrops
48. Case studies: Plantationcrops
49. Case studies: Foragecrops
50. Case studies: Tuber crops and Medicinal Plants.

Course outcome:

CO 1: Analyze and evaluate literature involving Origin and evolution of species.

CO2: Knowledge about centers of diversity, speciation, domestication and significance of micro-mutations and polyploidy in genetic improvement of crop plants.

CO3: Manage polyploidy to maximize progress for accomplishment of breeding objectives in genetic improvement of crop plants.

CO4: Analyze and Designing of new crop species.

CO5: To analyze the case studies followed for new crops

CO-PO Mapping matrix

	PO1	PO2	PO3	PO4	PO5
CO1	1				

CO2			3		
CO3				4	
CO4		2			
CO5			3		

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GPB 608 - BREEDING DESIGNER CROPS - (1+1)

Learning objectives

- This course helps the student to enlightens about developing varieties for special traits, physiological efficiency and nutritional enhancement.
- To get an idea about the industrial/pharma applications in plant breeding.
- To impart theoretical knowledge and practical know-how towards physiological efficiency, nutritional enhancement, biofortification
- To developvarietiesforspecialtraitshavinghightherapeuticandnutracetricalvalue.
- To study about the concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products.

Theory

Unit I: Ideotype breeding

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds - proteins, vaccines, gums, starch and fats.

Unit II: Principles of physiology

Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and it's significance in crop improvement; Breeding for special traits, viz., oil, protein, vitamins, amino acids, etc.; Eco specific ideotypes, Ideotypes for high and low moisture conditions, low and high input conditions, conversion mechanism of C_3 to C_4 plants; Determination of genetics of above mentioned traits.

Unit III: Growth and deveopement

Improvement in yield potential under sub-optimal conditions by manipulating

source and sink, canopy architecture, plant-water relationships, effect of sub optimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

Unit IV: Bioproduct industries

Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming.

Unit V: Post harvest technology

Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

Practicals

Demonstration of plant responses to stresses through recent techniques; Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/drought/ salt shock proteins.

Lesson plan

Theory lecture schedule

1. Ideotype breeding concept
2. Genetic manipuilation through recombination breeding
3. Genomics and transgenics for physiological efficiency, nutritional enhancement – protein starch and fat
4. Physiologicalefficiencyconcept
5. Physiological mechanism of improvement in nutrient use efficiency,water use efficiency, osmotic adjustment, photosynthetic efficiency
6. Breeding for special traits,viz.,oil,protein, vitamins, amino acids
7. Ecospecificideotypes, Ideotypes for high and low moisture conditions
8. **First test**
9. Differnciation of C3& C4 mechanism
10. conversion mechanism ofC_3toC_4plants
11. source and sink relationship
12. Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products
13. Success stories in vaccines, modified sugars, gums and starch through biopharming.
14. Biosafety management in designer crops
15. segregation and isolation requirements in designer crops
16. Designer crop improvement
17. post-harvestmanagement in designer crops

Practical schedule

1. Demonstration of plant responses to stresses through recent techniques
2. Estimation of Water use efficiency
3. Estimation of transpiration efficiency using portable photosynthetic system.
4. Basic screening techniques unde rsaline, Drought, Submergence and Heat
5. Demonstrate the process of plasmolysis using onion cells
6. Determine the percentage of water imbibed by pulses
7. Plant photosynthetic pigments by chromatography
8. Heat shock proteins
9. Estimation of Chlorophyll stability index
10. Difference between C3 & C4 plants
11. Estimation of Chlorophyll content in plants

12. Proline estimation in plants
13. Drought screening techniques for cereals, pulses and oil seeds
14. Saline screening tecniques for cereals, pulses and oil seeds.
15. Screening for heatstress under field conditions
16. Identificification of substances through HPLC techniques
17. Orientation of Final examinations

Course outcomes

CO 1: The students will be able to know about physiological efficiency and nutrient enhancement
CO 2: To know about the concept of biopharming and development of varieties fort industrial purposes
CO 3: Able to know about the special traits having high therapeutic and nutracetrical value
CO 4: to know about the screening techniques under different stress conditions
CO 5: Students will get an idea about Post harvest management techniques.

CO-PO Mapping matrix

	PO1	PO2	PO3	PO4	PO5
CO1	-	-	-	3	2
CO2	2	1	-	1	2
CO3	3	-	-	-	3
CO4	2	-	2	3	-
CO5	1	-	-	-	2

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GPB 610 - HYBRID SEED PRODUCTION TECHNOLOGY - (2+1)

Learning objectives

- To provide a basic concepts of hybrid seed production
- To know about the utilization of heterosis in hybrid development
- To impart knowledge on development and maintenance of inbred lines
- To know about the sterility system in hybrid seed production

- To provide students a comprehensive knowledge and practical exposure on hybrid seed production techniques in agricultural and horticultural crops.

Theory

Unit I introduction, history and importance

Introduction – history – scope – importance of hybrid development – national and international scenario of seed industry – popular public sector hybrids in various crops. modes of pollination - heterosis – definition – expression – types – utilization of heterosis in hybrid development, hybrid vigour and seed vigour.

Unit II Development of hybrids

Types of hybrids – intra-specific, inter-specific hybrids, single, double, three way cross, top cross hybrids – apomixes; generation system of seed multiplication in different types of hybrids. Development and maintenance of inbred lines – male sterile – maintainer lines – fertility restoration – transgenic hybrids – principles and method of development.

Unit III breeding tools and its application

Breeding tools – genetic mechanism – male sterility - types: CMS, GMS, GMS, TGMS, PGMS – barnase and barstar system – pistillateness –self-incompatibility. manual creation of male sterility – emasculation and pollination – gametocides – mode of action, mechanism. Synchronization of flowering – problems – methods to achieve synchrony – planting ratio and supplementary pollination methods.

Unit IV Techniques of hybrid seed production in major agricultural crops.

Techniques of hybrid seed production in agricultural crops – wheat, rice, maize, sorghum, bajra, ragi, panivaragu, samai, tenai, varagu, kudiraivalli, red gram, black gram, chickpea, Bengal gram, sunflower, castor, mustard, groundnut, cotton and foragecrops.

Unit V Techniques of hybrid seed production in major horticultural crops.

Hybrid seed production techniques in horticultural crops – tomato, brinjal, chilli, bhendi, onion, radish, bitter gourd, bottle gourd, ridge gourd, cucumber, melon, cabbage, cauliflower, potato, sweet potato, coconut and papaya.

Practicals

Characteristics features of parental lines and their hybrids-Floral biology of rice, maize, pearlmillet, sunflower, castor and cotton – Study on floral biology of vegetable crops– solanaceous and other vegetables – Study on floral biology of cucurbitaceous crops-Production and maintenance of A, B and R lines-Practicing planting design and border rows – rice, maize, pearl millet, sunflower and redgram; brinjal and chillies-Practicing planting design and border rows in tomato, cotton and cucurbitaceous vegetables-Manipulation for synchronization – rice, sunflower, pearlmillet and sorghum-Practicing supplementary pollination – rice and sunflower –Practicing field in section in hybrid seed production plot – crops planted in ratio – sunflower, pearlmillet, sorghum, etc –Practicing field inspection in hybrid seed production in field –redgram, castor, cotton, cucurbits and tomato – Practicing rouging and identification of off-types – pollen shedders –shedding tassel – selfed fruits – Visit to hybrid seed production fields-Visit to potato seed production plots –Determination of cost benefit of hybrid seed production-Visit to seed Industry and assessing problems and perspectives in hybrid seed production - orientation for final practical examination

Lesson plan

Theory lecture schedule

1. Introduction, history, scope and importance of hybrid development.
2. National and international scenario of seed industry – popular public sector hybrids in various crops.
3. Modes of pollination – pollen viability, storage and stigma receptivity
4. Heterosis – definition, expression and its types

5. Utilization of Heterosis in hybrid development, hybrid vigour and seed vigour.
6. Types of hybrids – intra-specific, inter-specific hybrids, single, double, three way cross, top cross hybrids – apomixes;
7. Generation system of seed multiplication in different types of hybrids.
8. Development and maintenance of inbred-lines – malesterile – maintainer lines – fertility restoration
9. Transgenic hybrids – principles and method of development.
10. Breeding tools – genetic mechanism – male sterility –types: CMS, GMS, CGMS, TGMS, PGMS – barnase and barstar system – pistillateness.
11. Self incompatibility - Manual creation of male sterility–emasculation and pollination – gametocides – mode of action and mechanism.
12. Synchronization of flowering – problems – methods to achieve synchrony–planting ratio and supplementary pollination methods.
13. Techniques of hybrid seed production in agricultural crops–rice and wheat
14. Techniques of hybrid seed production in agricultural crops – maize and sorghum,
15. Techniques of hybrid seed production in agricultural crops – Bajra and ragi
16. Techniques of hybrid seed production in agricultural crops - panivaragu, samai, tenai, varagu and kudiraivalli.
17. **First test**
18. Techniques of hybrid seed production in agricultural crops - Red gram
19. Techniques of hybrid seed production in agricultural crops - Black gram and green gram
20. Techniques of hybrid seed production in agricultural crops – cowpea and Bengal gram
21. Techniques of hybrid seed production in agricultural crops – Sunflower and safflower
22. Techniques of hybrid seed production in agricultural crops - Castor
23. Techniques of hybrid seed production in agricultural crops - Mustard and groundnut
24. Techniques of hybrid seed production in agricultural crops - Cotton
25. Techniques of hybrid seed production in forage crops.
26. Hybrid seed production techniques in horticultural crops – Tomato
27. Hybrid seed production techniques in horticultural crops - Brinjal
28. Hybrid seed production techniques in horticultural crops - Chilli
29. Hybrid seed production techniques in horticultural crops - Bhendi
30. Hybrid seed production techniques in horticultural crops – Onion and Radish
31. Hybrid seed production techniques in horticultural crops – Bitter gourd, bottle gourd and ridge gourd.
32. Hybrid seed production techniques in horticultural crops – Cucumber pumpkin and melons
33. Hybrid seed production techniques in horticultural crops - Cabbage, cauliflower, potato and sweet potato
34. Hybrid seed production techniques in horticultural crops - Coconut and papaya

Practical schedule

1. Characteristics features of parental lines and their hybrids.
2. Floral biology of rice, maize, pearl millet, sunflower, castor and cotton.
3. Study on floral biology of vegetable crops – solanaceous and other vegetables.
4. Study on floral biology of cucurbitaceous crops.
5. Production and maintenance of A, B and R lines.

6. Practicing planting design and border rows – rice, maize, pearlmillet, sunflower and red gram; brinjal and chillies.
7. Practicing planting design and border rows in tomato, cotton and cucurbitaceous vegetables.
8. Manipulation for synchronization – rice, sunflower, pearlmillet and sorghum.
9. Practicing supplementary pollination – rice and sunflower.
10. Practicing field inspection in hybrid seed production plot – crops planted in ratio – sunflower, pearlmillet, sorghum, etc.
11. Practicing field inspection in hybrid seed production field – red gram, castor, cotton, cucurbits and tomato.
12. Practicing rouging and identification of off-types – pollen shedders – shedding tassel – selfed fruits.
13. Visit to hybrid seed production fields.
14. Visit to potato seed production plots.
15. Determination of cost benefit of hybrid seed production.
16. Visit to seed Industry and assessing problems and perspectives in hybrid seed production.
17. Orientation for final practical examination.

Course outcome

CO 1 - Students will acquire a knowledge on importance of hybrid seed production
CO 2 - Learn about the hybrid development through utilization of heterosis
CO 3 - Gain knowledge on development and maintenance of inbred lines
CO 4 - Imparts knowledge on male sterility, self compatibility and its mechanism in hybrid seed production.
CO 5 - By learning this course, students will acquire a comprehensive knowledge and practical skills on hybrid seed production techniques both in agricultural and horticultural crops

CO-PO Mapping matrix

	PO1	PO2	PO3	PO4	PO5
C01	-	3	-	-	2
C02	-	3	-	-	1
C03	-	2	-	-	-
C04	1	2	-	-	-
C05	1	3	1	-	2

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GPB 611 - COMMERCIAL PLANT TISSUE CULTURE - (2+0)

Learning objective

- To provide awareness into development of commercial scale plant tissue culture units.
- To provide an insight into the commercial applications of plant tissue culture in agriculture.
- To apply commercial plant tissue culture in medicine and industry.
- To educate about bio-safety and their regulatory.
- To know about entrepreneurship as well as opportunities.

Theory

Unit I Micro-propagation in plants

Micro-propagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

Unit II Secoundary production tchinquies

Production of useful compounds via, biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry.

Unit III Transgenic plants production

Value-addition by transformation; development, production and release of transgenic plants; patent, bio safety, regulatory, environmental and ethical issues; management and commercialization.

Unit IV Commercial applications of plant tissueculture-i

Project planning and preparation, economics (entrepreneurship, cost profit ratio), government policies (incubators, different facilitation projects, loan opportunities).

Unit V Commercial applications of plant tissue culture-ii

Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

Lesson plan

Theory lecture schedule

1. Micro-propagation of commercially important plant species
2. Somatic plants multiplication
3. Hardening in greenhouse
4. Field transplantation of somatic plants
5. Phenotyping analysis of somatic plants
6. Genetic fidelity analysis of somatic plants
7. Marketing of tissue cultured plants
8. Plants as Bioreactors
9. Production of Cotyledonary somatic embryos
10. **First Test**
11. Synthetic seeds using cotyledonary somatic embryos

12. What are biotransformation
13. Principle of Suspension cultures
14. Mechanism of Immobilization
15. Secondary metabolite through callus –suspension culture
16. Production of useful compounds by using biotransformation.
17. Production of useful compounds by using secondary metabolite.
18. Production of useful compounds by using immobilization.
19. Examples of chemicals being produced for use in pharmacy, medicine and industry.
20. **Mid semester examination**
21. Value-addition by biotransformation
22. List of commercialized transgenic plants
23. Development, production and release of transgenic plants.
24. Patent in commercial tissue culture
25. Bio-safety of tissue and transgenic plants
26. Regulatory bodies in tissue culture and transgenics
27. Environmental and ethical issues
28. Management and commercialization.
29. Project planning and preparation
30. Economics (entrepreneurship, cost profit ratio)
31. Government policies (incubators, different facilitation projects, loan opportunities).
32. Some case studies on success stories on commercial applications of plant tissue culture.
33. Success stories on commercialization of tissue culture banana
34. Visits to some tissue culture based commercial units/industries.

Course outcomes

CO 1 - Standardize protocols for the invitro propagation from exvitro explants
CO 2 - To optimize the culture conditions for rapid propagation and regeneration of agriculturally important plants.
CO 3 - Bio chemical monitoring of explants proliferation and regeneration
CO 4 - Optimization of medium and culture conditions for the enhancement of active principle production. And acquire knowledge for commercial tissue culture laboratory.
CO 5 - Biochemical characterization of regeneration and genetic transformation using Agro bacterium.

CO-PO Mapping matrix

	PO1	PO2	PO3	PO4	PO5
CO1			**1**		
CO2			**1**		
CO3			**1**	**3**	**2**
CO4			**1**		
CO5			**1**	**2**	**3**

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GPB 612 - PLANT HORMONES AND SIGNALLING - (2+0)

Learning objectives:

- To provide in-depth knowledge of plant hormone biosynthesis, metabolism and its regulation at molecular level.
- Impart knowledge on functioning of hormones and their role in plant growth and development at cellular level.
- Make them to expertise in analysis of plant hormones using modern techniques.
- To teach the importance of endogenous growth substances other than hormones on senescence and defense mechanism.
- To understand the hormone signalling in plant parasitism and symbiosis.

Theory

UNIT I : Hormone biosynthesis, metabolism and its regulation

Auxin biosynthesis and metabolism, Gibberellin biosynthesis and Inactivation, Cytokinin biosynthesis and metabolism, Ethylene biosynthesis, Abscisic acid biosynthesis and metabolism, Brassinosteroid biosynthesis and metabolism. Salicylic acid and jasmonate biosynthesis and metabolism.

UNIT II: Functioning of hormones in plant growth and development

Transport of Auxins, Induction of vascular tissues by Auxin, Hormones and the regulation of water balance, seed development and germination, Hormonal control of day length and senescence.

UNIT III: Action of hormones

Hormones in defense against insects and disease; Role of jasmonates, salicylic acids and peptide hormones for defense, growth, development and reproduction; Methods of plant hormone analysis. NPR 1 dependent Salicylic acid signalling, PAMP and effector triggered immunity, systemic acquired resistance and SA signalling.

UNIT IV: Endogenous growth substances other than hormones

Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent

developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level.

UNIT V: Hormone signal transduction

Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction, Gibberellin biosynthesis, transport, signal transduction in stem elongation & Leaf Growth, Ethylene metabolism, perception and signaling in seedling growth and development, Ethylene signal transduction in fruits and flowers, Abscisic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses. Brassinosteroid biosynthesis, catabolism and signal transduction. Strigalactone biosynthesis, transport and signaling in plant parasitism and symbiosis. Methods of Plant Hormone Analysis: Quantitative analysis of plant hormones based on LC/MS.

Lesson plan

Theory lecture schedule

1. Plant hormones - importance – kinds and their role
2. Auxin biosynthesis and metabolism
3. Gibberellins biosynthesis and inactivation
4. Cytokinin biosynthesis and metabolism
5. Brassino steroid biosynthesis and metabolism
6. Salicylic acid and jasmonate biosynthesis and metabolism
7. Transport of auxin and induction of vascular tissues
8. Hormones and its regulation in water balance, seed development and germination
9. Hormonal control over day length and senescence
10. Role of hormones in defense mechanism against insects
11. Role of hormones in defense mechanism against diseases
12. Role of jasmonates on growth and development
13. Methods of plant hormone analysis on reproduction
14. NPR 1 dependent salicylic acid signalling
15. PAMP and effector triggered immunity
16. Systemic acquired resistance
17. **First test**
18. SA signalling at cellular level
19. Biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins
20. Biosynthetic pathways metabolism and physiological role of Jasmonates and Tricantanol
21. Biosynthetic pathways metabolism and physiological role of Peptide hormones and systemins
22. Concept of death hormone
23. Recent developments in elucidating responses of Salicylic acid at physiological and molecular level
24. Recent developments in elucidating responses of peptide hormones at physiological and molecular level
25. Recent developments in elucidating responses of Jasmonates at physiological and molecular level
26. Recent developments in elucidating responses of Systemins at physiological and molecular level
27. Recent developments in elucidating responses of Karrikins at physiological and molecular level
28. Recent developments in elucidating responses of Tricantanol at physiological and molecular level
29. Auxin metabolism, transport and signal transduction

30. Cytokinin types, synthesis, metabolism, transport and signal transduction
31. Ethylene metabolism, perception and signaling in seedling growth and development
32. Abscissic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses
33. Plant Hormone Analysis
34. Quantitative analysis of plant hormones based on LC/MS.

Course outcome:

CO 1: Gaining knowledge on importance of biosynthesis and metabolism of plant hormones on growth and development at molecular level

CO 2: To know about the hormonal signalling as defense mechanism against biotic and abiotic stresses at genetic level

CO 3: Help them to understand hormonal influence on various stages of plant development at physiological and cellular level

CO 4: Well known about various hormonal signal transduction in nuclear gene expression during various stages of crop plants

CO 5: Proficiency in assessing and analyzing techniques of plant hormones using innovative methods

CO-PO Mapping matrix

	PO1	PO2	PO3	PO4	PO5
CO1	2		2	3	
CO2	1		1		
CO3		1			2
CO4		1		2	
CO5	3	3	1		

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GPB 613 SEED VIGOUR AND CROP PRODUCTIVITY 2 (1+1)

Learning objectives

- To impart knowledge on real planting value of seed
- To make scholars understand the concept of seed vigour
- To appraise the scholars with knowledge about impact of seed vigour on seed production
- To impart the knowledge about different vigour test and its history
- To promulgate knowledge about mechanism involved in manifestation of seed vigour under stress condition

Theory

Unit I: Introduction

Seed vigour – importance, concepts, definitions, vigour vs viability, historical development – ISTA vigour committee. Factors influencing seed vigour – genetic, agronomic, biotic and abiotic factors.

Unit II: Seed vigour manifestation

Seed vigour and senescence – sequence of vigour loss – manifestations of seed vigour – physical, physiological, biochemical and molecular manifestations; vigour in relation to seed dormancy and germination; vigour in relation to value for cultivation and use.

Unit III: Types of seed vigour tests

Vigour tests – history – definition – characteristics – types – direct and indirect tests – physical test – x-ray radiography, seed size; physiological test – seedling first count, radicle emergence, speed of germination, seedling measurement; stress tests – brick gravel test, cool test, cold test, paper piercing test, ethanol, ammonium chloride and NaCl soak tests, accelerated ageing test, exhaustion test, controlled deterioration test, osmotic stress test.

Unit IV: Chemical and biochemical vigour test

Chemical and biochemical tests – electrical conductivity test, free sugars and amino acids, tetrazolium chloride test, respiration quotient, GADA test, free fatty acid, DPPH, respiratory and hydrolytic enzymes tests, modern vigour tests – machine vision, Q2 analyzer – standardization of vigour test

Unit V: Seed vigour field performance

Influence of seed vigour – crop growth, field emergence, productivity and storage; vigour of vegetative propagules ; role of seed vigour in field emergence, crop growth, yield and productivity. Seed vigour improvement and management techniques – pre-sowing and pre-storage – mid storage methods to improve seed vigour.

Practicals

Collection and evaluation of germination of seed lots with different vigour status; Evaluation of seed vigour by physical vigour test – seed size, colour, weight –turbidity test; Evaluation of seed vigour by physiological vigour test – imbibition pattern, speed of emergence, radical emergence, germination, seedling measurement and computation of various indeX; Conducting different stress tests– brick gravel and paper piercing tests; Conducting accelerated ageing and controlled deterioration test; Conducting chemical stress test – NH_4Cl, NaCl, mannitol, PEG test; Special vigour tests–cool germination test – cold test – anaerobic test; Biochemical vigour test – electrical conductivity, free sugars and aminoacid test in seed leachate; Estimation of dehydrogenase enzyme activity; Estimation of free fattyacids in seed lots in varying vigour levels; Bio-assay test for seed vigour;

Estimation of volatile aldehydes in different crop seeds with varying vigour; Correlation studies between field emergence and different vigour tests; Seed vigour on field establishment, population maintenance and crop growth and productivity; Pre-sowing vigour management techniques; Pre-storage and mid storage vigour management techniques.

Lesson plan

Theory lecture schedule

1. Seed vigour – Concepts of Seed vigour and its importance and Definitions, Vigour vs viability,
2. Historical development ISTA vigour committee.
3. Factors influencing seed vigour genetic, agronomic, biotic and abiotic factors.
4. Seed vigour and senescence -Sequence of vigour loss
5. Manifestations of seed vigour physical, physiological, biochemical and molecular manifestations.
6. Vigour in relation to seed dormancy and germination value for cultivation and use.
7. Vigour tests - history- definition and characteristics, Types – direct and indirect tests
8. **First test**
9. Physical, Physiological and Stress test for vigour.
10. Chemical and biochemical test for seed vigour
11. Enzyme test for seed vigour
12. Modern vigour test
13. Influence of seed vigour – crop growth, field emergence, productivity and storage.
14. Vigour of vegetative propagules
15. Role of seed vigour in field emergence, crop growth, yield and productivity
16. Seed vigour improvement and management techniques – Presowing methods
17. Pre-storage and Mid -storage methods to improve seed vigour

Practical schedule

1. Collection and evaluation of germination of seed lots with different vigour status
2. Evaluation of seed vigour by physical vigour test – seed size, colour, weight turbidity test
3. Evaluation of seed vigour by physiological vigour test – imbibition pattern, speed of emergence, radicle emergence, germination, seedling measurement and computation of various index
4. Conducting different stress tests – brick gravel and paper piercing tests
5. Conducting accelerated ageing and controlled deterioration test
6. Conducting chemical stress test – NH_4Cl, NaCl, mannitol, PEG test
7. Special vigour tests – cool germination test – cold test – anaerobic test
8. Biochemical vigour test – electrical conductivity, free sugars and amino acid test in seed leachate
9. Estimation of dehydrogenase enzyme activity
10. Estimation of free fatty acids in seed lots in varying vigour levels
11. Bio-assay test for seed vigour
12. Estimation of volatile aldehydes in different crop seeds with varying vigour.
13. Correlation studies between field emergence and different vigour tests
14. Seed vigour on field establishment, population maintenance and crop growth and productivity
15. Pre-sowing vigour management techniques
16. Pre-storage and mid storage vigour management techniques.
17. **Final Practical Examination**

Course outcomes

CO 1 - Scholar refresh knowledge about concept of seed vigour and its manifestation
CO 2 - Scholar understands the real planting value of seed
CO 3 - Scholar enhances the skills to predict and assess the seed vigour
CO 4 - Scholar understands influence of seed vigour on crop productivity
CO 5 - Scholar understands management techniques to improve seed vigour

PO-CO Mapping matrix

	PO1	PO2	PO3	PO4	PO5
CO1	-	-	-	-	**2**
CO2	**1**	-	-	-	-
CO3	-	-	-	-	-
CO4	-	-	-	-	**3**
CO5	-	-	-	-	-

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3. https://link.springer.com/chapter/10.1007/978-1-4615-1783-2_7
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COM 601 - ADVANCES IN COMPUTING APPLICATIONS - (1+1)

Learning objectives

- To acquaint the students with open source tool, Latex typesetting language, Python and its usage in the industry

Theory

Unit I Introduction to Latex:

Introduction to Latex – What is Latex – Document Structure, Start Text works, Title, Section, Table of content – Typesetting Text, Font Effects, Coloured Text, Font Size, List, Comments & Spacing, Special Charcters.

Unit II Packages and Classes in Latex:

Inserting Equations – Mathematical Symbols – Table of Content – Generating New

Command – Figure handling numbering, List of figure, List of Tables. Packages – Geometry, Hyperref, amsmath, amssymbol – Classes – Article, Book, report - The BibTex file – Inserting Bibliography – Citing – References.

Unit III MS Access:

MSACCESS: Database, concepts and types - Uses of DBMS in Agriculture; creating database.

Unit IV Introduction to Python:

Python Introduction, Technical Strength of Python, Introduction to Python Interpreter and program execution, Using Comments, Literals, Constants, Python's Built-in Data types, Numbers (Integers, Floats, Complex Numbers, Real, Sets), Strings (Slicing, Indexing, Concatenation, other operations on Strings), Accepting input from Console, printing statements, Simple 'Python' programs.

Unit V Using Databases in Python:

Database Programming: Connecting to a database, Creating Tables, INSERT, UPDATE, DELETE and READ operations, Transaction Control, Disconnecting from a database.

Theory Lecture Schedule

1. Introduction to Latex.
2. Document Structure.
3. Classes.
4. Typesetting Text.
5. Inserting Equations
6. Packages and Mathematical Symbols.
7. List of figure.
8. List of Tables.
9. **First Test**
10. Bibliography and References.
11. MS Access Concepts of Database, Creating Database.
12. DBMS in Agriculture.
13. Introduction to Python.
14. Built-in Data types.
15. Strings.
16. Python Console.
17. Database in Python.

Practical Schedule

1. Installation of Latex
2. Basic Latex commands
3. Latex Compilation, Page Layout
4. Building a Latex document, Previewing first.tex
5. Addition of some text in the.tex file, Finding the error and fixing it
6. Type setting of mathematics
7. Writing equations, matrix
8. Two figure next to each other, Formation of table
9. Typesetting with a new chapter heading, List of figures, List of tables
10. Citation, Bibliography, printing your document
11. MSACCESS: Creating Database, preparing queries and reports
12. MSACCESS: Demonstration of Agri-information system
13. Introduction to Python, Working with Data
14. Program Organization, Functions, and Modules, Classes and Objects
15. Inside the Python Object System

16. Testing, Debugging, and Software Development Practice
17. Packages

Course Outcome

CO 1: Problem solving and programming capability
CO 2: Analyse common problems using Latex
CO 3: Learn categories of programs
CO 4: Construct and execute basic programs in Python
CO 5: Use external libraries and packages with Python

CO-PO Mapping matrix

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

Reference

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2. LaTeX: A Document Preparation System, 2nd Edition By Leslie Lamport
3. Charles Dierbach, "Introduction to Computer Science using Python", Wiley, 2015
4. Python Programming- A modular Approach (with Graphics, database, Mobile and Web Applications by Sheetal Taneja and Naveen Kumar, Pearson.
5. Head First Python by Paul Berry, O'Reilly

e-resources

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3. https://wiki.python.org/moin/PythonBooks.
4. https://devfreebooks.github.io/python/
5. https://www.digitalocean.com/community/books/digitalocean-ebook-how-to-code-in-python.

STA 601 - ADVANCES IN DESIGN OF EXPERIMENTS - (2+1)

Learning objective

- To acquaint the students to understand the concepts of statistical hypothesis, design of experiments, statistical methods, data collection, analysis and interpretation of results and to acquire Multivariate Statistical Analysis skills.

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. Current trends in design of Experiments.

Practicals

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. **First Test**
18. Cluster analysis, Classification by linear discriminant function.
19. Canonical correlations, Principal components.
20. Factor analysis, multi- dimensional scaling and Correspondence Analysis.
21. Hierarchical clustering.
22. Principal component analysis.
23. Need for design of experiments, characteristics of a good design.
24. Basic principles of designs - randomization, replication and local control.
25. Uniformity trials, size and shape of plots and blocks; Analysis of variance and covariance; partitioning of degrees of freedom.
26. Completely randomized design, randomized block design and Latin square design.
27. Factorial experiments: Layout and analysis of factorial experiments.
28. Complete block design – split – plot design.
29. Strip-plot design: split split –plot design.
30. Resolvable block designs and their applications.
31. Randomization procedure, analysis and interpretation of results.
32. Analysis of covariance. Missing plot technique and its application to RBD, LSD.
33. Factorial experiments (symmetrical as well as asymmetrical).
34. Factorial experiments with control treatment. 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: Gaining knowledge on basic and recent concepts of statistical methods
CO 2: Proficiency in data Collection, analysis and interpretation of results
CO 3: Understanding the testing of statistical hypothesis
CO 4: Knowledge on multivariate statistical analysis
CO 5: Design of experiments in agricultural field and data for analysis

CO - PO Mapping matrix

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

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