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 SEED SCIENCE AND TECHNOLOGY

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. Molecular Biology and Biotechnology
13. Plant Pathology
14. Seed Science and Technology
15. Soil Science

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	M.Sc. (Ag.) in Soil Science

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 pursue his research work in Annamalai University or in other Universities/Research Institutes by entering with/without MOU between Annamalai University and the partner University/Institute 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 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 Card: 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 major **Advisor/Research Advisor** will be from Annamalai University and Co-Research Supervisor will be from the partner institutes (Research Scholars pursuing in other institutes/universities) besides RAC members.

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.

12.2.1 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.

12.2.2. The question paper for the final examination will be set as per Bloom's taxonomy by the concerned course teacher in consultation with the Head of the Department.

12.2.3 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 (four questions must represent K6 level of Bloom's taxonomy)	(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 (four questions must represent K6 level of Bloom's taxonomy)	(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.

****

GGPB 81 – Ph.D. in SEED SCIENCE AND TECHNOLOGY

PROGRAMME OUTCOME

PO 1	Learn the composition of seed, its structure, development and maturation and their importance in maintaining seed quality under different ecosystem.
PO 2	students will acquire knowledge on principles and mechanism of recent advanced enhancement techniques and scientific principles involved in hybrid seed production of agricultural and horticultural crops
PO 3	To promulgate knowledge about the concept and scientific principles of organic seed production as well as the scope of organic seed production making them to become entrepreneurship.
PO 4	To initiate basic methods and principle related to genetic purity assessment and protection of plant varieties.
PO 5	To disseminate the knowledge on importance of seed physiological quality (Viability and vigour) on crop productivity and germplasm conservation.

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 7 major courses)	12
SST 601#	Hybrid Seed Production Technology	3 (2+1)
SST 602	Organic Seed Production	2 (1+1)
SST 603	Physiology and Biochemistry of Seeds	2 (1+1)
SST 604#	Genetic Purity and DUS Testing	3 (2+1)
SST 606#	Advances in Seed Science	2 (2+0)
SST 610	Seed Planning, Trade and Marketing	2 (1+1)
SST 611	Crop Evolution	3(3+0)
	# Compulsory Course	
	Minor Course (Any 3 out of 5 minor courses)	6
SST 605	Seed Vigour and Crop Productivity	2 (1+1)
SST 607	Advances in Seed Quality Enhancement	2 (1+1)
SST 608	Germplasm Conservation Techniques	2 (1+1)
SST 609	Seed Ecology	2 (1+1)
SST 612	Commercial Plant Tissue Culture	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**

SST601 – 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 vigor and seed vigor.

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. **First test**
10. Transgenic hybrids – principles and method of development.
11. Breeding tools – genetic mechanism – male sterility –types: CMS, GMS, CGMS, TGMS, PGMS – barnase and barstar system – pistillateness.
12. Self incompatibility - Manual creation of male sterility–emasculation and pollination – gametocides – mode of action and mechanism.
13. Synchronization of flowering – problems – methods to achieve synchrony–planting ratio and supplementary pollination methods.
14. Techniques of hybrid seed production in agricultural crops–rice and wheat
15. Techniques of hybrid seed production in agricultural crops – maize and sorghum,
16. Techniques of hybrid seed production in agricultural crops – Bajra and ragi
17. Techniques of hybrid seed production in agricultural crops - panivaragu, samai, tenai, varagu and kudiraivalli.
18. Techniques of hybrid seed production in agricultural crops - Red gram
19. Techniques of hybrid seed production in agricultural crops - Black gram, 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. **C**haracteristics 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. Final Practical examination.

Course outcomes

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

References

1. Agarwal RL. 2012. Seed Technology. 3rd Ed. Oxford & IBH Publishers, New Delhi.
2. Basra A. 1999. Heterosis and Hybrid Seed Production in Agronomic Crops. CRC Press., Florida, United States.
3. Dar SH. 2018. Methods of Hybrid Seed Production in Major Crops. Educreation Publishing, Chhattisgarh.
4. Frankel R and Galun E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer Verlag, New York.

5. Joshi AK and Singh BD. 2004. Seed Science and Technology. Kalyani Publishers, New Delhi.
6. Krishnan M. 2012. Plant breeding and Hybrid Seed Production. Domin and Publishers & Distributors, New Delhi, India.
7. Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi.
8. McDonald MF and Copeland LO. 2012. Seed Production: Principles and Practices. Springer Science and Business Media, Boston, United States.
9. Mondal SS, Saha M and Sengupta K. 2009. Seed Production of Field Crops. New India Publishing Agency, New Delhi.
10.Singhal NC. 2003. Hybrid Seed Production. Kalyani Publishers., New Delhi, India.

e-resources

1. https:// springer.com/in/book/9780792373223
2. https://springer.com/in/book/9780412075513
3. https://nipabooks.com/info/9788190723763/seed-production-of-field-crops
4. https://kopykitab.com/Vegetable-Hybrid-Seed-Production-And-Management
5. https://researchgate.net/publication/229432295_Hybrid_Seed_Production and_Flowers

SST 602 - Organic Seed Production - (1+1)

Learning objectives

- To understand the concept of organic seed production
- To describe the principles and practices of organic seed production
- To perceive about post harvest management techniques for organic seeds
- To aware the organic seed certification and marketing
- To recognize the value of organic seed production

Theory

Unit: I; Significance of Organic seeds and their complication

Organic farming – definition, genesis, concepts and principles; importance of organic farming and organic seed, organic seed: strategies, problems and perspectives organic seed *vs* conventional seed; organic seed production – factors influencing seed production –soil health – GMO elements of seed.

Unit: II; Plan of action for organic seed production

Techniques of organic seed production – selection of land – pre requisite for seed production – conversion period – soil amendments – green manures; multi-varietal seed techniques–organic sources of manures–bulky, concentrated and liquid manures, bio-fertilizer and bio-control agents – organic seed treatment.

Unit: III; Guidance for high quality production of organic seed

Organic weed management practices – manual and mechanical methods–mulching–thermal weed control; growth promoting substances– panchakavya, fish aminoacid, etc.; organic plant protection measures – herbal insecticides –IPM strategies; post harvest techniques –drying, processing and grading; organic seed treatment and storage.

Unit: IV; Organic seed certification procedures and seed movement

Organic certification application – registration – verification of records; organic seed certification – tagging; role of organizations in production and marketing of organic seed – national and international organizations involved – public, private –NGOs – International Federation of Organic Agriculture Movement (IFOAM) – basic standards and EU regulations–organic seed marketing.

Unit: V ; Post harvest techniques and demand of organic seeds

Crop specific organic seed production and post harvest seed management techniques for major food crops, vegetables and fruit crops –economics of organic seed production and demand for organic seed.

Practicals

Studying the field and seed standards for organic seed production. Collection of organic manures liquids. Preparation of organic products (*panchakavya*, vermiwash) for soil application and also for the organic seed treatment. Organic starter solutions and leaf extracts for foliar application. Understand the effect of organic nutrients and foliar sprays 0n good seed quality and organic products for seed treatment. Selection of suitable container and dry leaves or shrubs for enhanced storability of organically treated seeds and analyses the behavior organic seed. Organic treatment or management of seed health. Production and assessment of biocontrol agents for effective pest control. Economics of organic seed production and assessing demand. Visit to organic farm, seed production field, Department of organic certification and organic retail shops.

Lesson plan

Theory lecture schedule

1. Organic farming – definition, genesis, concepts and principles.
2. Importance of organic farming and organic seed
3. Organic seed – strategies, problems and perspectives–organic seed vs conventional seed
4. Organic seed production – factors influencing seed production – soil health–GMO elements of seed.
5. Techniques of organic seed production – selection of land – pre requisite for seed production – conversion period – soil amendments – green manures
6. Multi-varietal seed techniques – organic sources of manures –bulky, concentrated and liquid manures, biofertilizers and biocontrol agents–
7. Organic seed treatment for better establishment of plant
8. Organic weed management practices – manual and mechanical methods – mulching – thermal weed control ; growth promoting substances –*panchakavya*, fish aminoacid,etc
9. **First test**
10. Organic plant protection measures – herbal insecticides – IPM strategies
11. Post – harvest techniques – drying, processing and grading; organic seed treatment and storage.
12. Organic certification application – registration – verification of records- Organic seed certification – tagging
13. Role of organizations in production and marketing of organic seed – national and international organizations involved – public, private –NGOs
14. International Federation of Organic Agriculture Movement (IFOAM) –basic standards and EU regulations – organic seed marketing
15. Crop specific organic seed production
16. Post – harvest seed management techniques for major food crops, vegetables and fruit crops
17. Economics of organic seed production and demand for organic seed.

Practical schedule

1. Studying the field and seed standards for organic seed production
2. Collection and identification of organic manures and liquids
3. Preparation of organic products for soil application
4. Preparation of *panchakavya*, starter solutions and vermiwash
5. Organic priming of seeds with *panchakavya* and vermiwash

6. Preparation of leaf extracts and starter solutions and preparation of organic products for foliar application
7. Studying the effect of organic nutrients and foliar sprays on seed quality
8. Preparation of organic products for seed treatment and studying the effect on seed quality
9. Assessing the storage behavior of organically treated seeds
10. Selection of suitable container and dry leaves or shrubs for enhanced storability
11. Organic treatment for management of seed health
12. Production and assessment of biocontrol agents for effective pest control
13. Economics of organic seed production and assessing demand
14. Visit to organic farm and seed production field
15. Visit to Department of organic certification
16. Visit to organic retail shops.
17. **Final Practical Examination**

Course outcome

CO 1 - It helps the students to understand the basics of organic seed production
CO 2 - After completion of this course, students will gain knowledge, skill and confidence to take up organic seed production.
CO 3 - Impart knowledge on the principles and practices of organic seed production
CO 4 - Acquire knowledge about post-harvest techniques for organic seeds
CO 5 - The students gain confidence about organic seed certification and marketing

CO-PO Mapping matrix

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

References

1. Agrawal RL. 2019. *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.
2. Connolly, B. 2011. Organic Seed Production and Saving: The Wisdom of Plant Heritage. Chelsea Green Publishing. Chelsea Green Publishing, Inc. White River Junction, England.
3. Hebbleth waite PD.1980. *Seed Production*. Butterworth Heinemann Ltd., London, UK.
4. JoshiAK and Singh BD. 2004.*SeedScienceand Technology*. Kalyani Publishers, New Delhi.
5. McDonald MB and Copeland L. 1998. *Seed Production Principles and Practices*. CBS Publishers, New Delhi.
6. Navazio, J. (2012). *The Organic Seed Grower: A farmer's guide to vegetable seed production*. Chelsea Green Publishing. White River Junction, England.
7. Singhal NC.2010.*Seed Science and Technology*. Kalyani Publishers, New Delhi.
8. Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani Publications, New Delhi.
9. Singhal NC. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.
10. Vanangamudi K, Prabhu M, Kalaivani S, Bhaskaran M and Manonmani V. 2010. Vegetable Hybrid seed Production and Management. Agrobios., Jodhpur, India.

e-resources

1. https://eco-pb.org/fileadmin/eco-pb/documents/reports_proceedings/

proceedings_berlin_symposium.pdf
2. https://eorganic.org/node/378
3. https://academia.edu/4601825/Organic_seed_production
4. https://research.wur.nl/en/publications/organic-seed-production-certification-and-availability-corp-breed
5. http://arkgroup.arkgroup.co.in/upload/Article/4021%20rev.pdf

SST 603 - Physiology and Biochemistry of Seeds - (1+1)

Learning objectives

- To understand about the fundamental theories of seed development and maturation
- To provide insight knowledge on physiological and biochemical events governing seed quality and its survival.
- To know about seed dormancy and techniques for breaking dormancy
- To provide knowledge on seed germination and deterioration
- To initiate basic research related to seed physiology.

Theory

Unit: I; Seed development and maturation

Seed development and maturation – role of cell organelles – embryogeny – translocation of assimilates – synthesis of starch, protein, lipid, secondary metabolites and toxic compounds – possible alteration in metabolic pathway.

Unit: II; Embryo, endosperm and seed coat development

Development of embryo, endosperm and seed coat – translocation of assimilates and food reserves; desiccation tolerance – mechanism, hypothesis, role of LEA proteins; development of hard seeds – mechanisms and factors.

Unit: III; Seed dormancy

Seed dormancy – types – physiology and biochemistry of seed dormancy induction and release – hormonal regulation of seed dormancy – environmental control – genetic inheritance and control of dormancy; physiology of orthodox, recalcitrant and intermediate seeds.

Unit: I V ; Seed germination

Seed germination – acquisition of viability and capacity of germination during development – genetics of germination acquisition; types of germination – phases of germination – requirements – imbibition – enzyme activation and hormonal regulation – respiration – mitochondrial activity and ATP synthesis – protein and nucleic acid synthesis – metabolism of starch, protein, lipid – physiology of embryo growth and development.

Unit: V; Seed Deterioration

Seed deterioration – theories, causes – ultra-structural, cell membrane and functional changes; biochemical changes – enzyme activity, storage reserves and genetic changes; lipid peroxidation – biological effects – free radicals and secondary products.

Practicals

Study on the pattern of seed development and maturation - Study on the structural changes during seed maturation - Estimation of seed moisture content, fresh and dry weight and acquisition of germination and dormancy - Estimation of different hormones during seed development and maturation – GA and ABA - Estimation of phenolic compounds during seed maturity - Estimation of food reserves accumulation – starch, protein and oil at different stages of maturity - Study on the pattern of seed development in recalcitrant seeds - Studying the germination behaviour of different type of seeds - Study on imbibition pattern and soaking injury in seeds - Estimation of enzymes in dormant and non-dormant seeds - Estimation of

hormones in dormant and non-dormant seeds - Studying the effect of light and temperature on dormancy - Study on deterioration pattern of orthodox and recalcitrant seeds - Estimation of lipid peroxidation product and free fatty acid - Studying the cytological and chromosomal changes in deteriorated seeds - Estimation of volatile aldehydes during seed storage and deterioration

Lesson plan

Theory lecture schedule

1. Seed development and maturation – role of cell organelles – embryogeny – translocation of assimilates

2. Synthesis of starch, protein, lipid, secondary metabolites and toxic compounds – possible alteration in metabolic pathway

3. Development of embryo, endosperm and seed coat – translocation of assimilates and food reserves

4. Desiccation tolerance – mechanism, hypothesis ,role of LEA proteins

5. Development of hard seeds – mechanisms and factors

6. Seed dormancy – types – physiology and biochemistry of seed dormancy induction and release – hormonal regulation of seed dormancy

7. Environmental control – genetic inheritance and control of dormancy

8. Physiology of orthodox, recalcitrant and intermediate seeds

9. First test

10. Seed germination – acquisition of viability and capacity of germination during development – genetics of germination acquisition

11. Types of germination – phases of germination – requirements – imbibition - enzyme activation and hormonal regulation

12. Respiration – mitochondrial activity and ATP synthesis

13. Protein and nucleic acid synthesis

14. Metabolism of starch, protein, lipid – physiology of embryo growth and development

15. Seed deterioration – theories, causes – ultra-structural, cell membrane and functional changes

16. Biochemical changes – enzyme activity, storage reserves and genetic changes

17. Lipid peroxidation – biological effects – free radicals and secondary products.

Practical schedule

1. Study on the pattern of seed development and maturation
2. Study on the structural changes during seed maturation
3. Estimation of seed moisture content, fresh and dry weight and acquisition of germination and dormancy
4. Estimation of different hormones during seed development and maturation – GA and ABA
5. Estimation of phenolic compounds during seed maturity
6. Estimation of food reserves accumulation – starch, protein and oil at different stages of maturity
7. Study on the pattern of seed development in recalcitrant seeds
8. Studying the germination behaviour of different type of seeds
9. Study on imbibition pattern and soaking injury in seeds
10. Estimation of enzymes in dormant and non-dormant seeds
11. Estimation of hormones in dormant and non-dormant seeds
12. Studying the effect of light and temperature on dormancy
13. Study on deterioration pattern of orthodox and recalcitrant seeds
14. Estimation of lipid peroxidation product and free fatty acid

15.Studying the cytological and chromosomal changes in deteriorated seeds
16.Estimation of volatile aldehydes during seed storage and deterioration.
17.Final Practical Examination

Course outcome

CO 1: It will enable the students to understand the mechanism of seed development and maturation

CO 2: Impart knowledge on physiological and biochemical events governing seed quality and helps the students to understand the mysteries in seed to address the problems in quality seed production and storage.

CO 3: Study about the sources of assimilates and their translocation in the developing seed.

CO 4: Learn about the seed germination process and seed deterioration.

CO 5: It will be helpful for the students in estimating lipids, free fatty acid and volatile aldehydes during seed storage.

CO-PO Mapping matrix

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

References

1. Bewley JD and Black M. 1982. *Physiology and Biochemistry of Seeds in Relation to Germination* (Vol. I & II). Springer Verlage, Berlin Heldelberg, New York, United States.

2. Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. *Seeds: Physiology of Development*, Germination and Dormancy. Springer, New York.

3. Justice OL and Bass LN. 1978. *Principles and Practices of Seed Storage*. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.

4. Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.

5. Ovcharov KE. 1977. *Physiological Basis of Seed Germination*, Amerind Publishing Co,New Delhi and New York, United States.

6. Prakash M. 2011. *Seed Physiology of Crops*. Satish Serial Publishing house. Azadpur. New Delhi.

7. Barton LV. 1961. *Seed Preservation and Longevity*, (Vol. 1). Leonard Hill, London.

8. Baskin C and Baskin JM. 2014. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, Cambridge, UK.

9. Roberts EH. 1972. *Viability of seeds*. Springerlink, New York, USA.

10.Vanangamudi K. 2006. *Seed Physiology*. Associated Publishing Company, New Delhi, India.

e-resources

1. https://link.springer.com/chapter/10.1007/978-1-4615-1747-4_2
2. https://sciencedirect.com/topics/agricultural-and-biological-sciences/desiccation-tolerance
3. https://sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/embryogenesis
4. https://cell.com/current-biology/comments/S0960-9822(17)30562-6
5. http://biologyReferences.com/Re-Se/Seed-Germination-and-Dormancy.html

SST 604 - Genetic Purity and DUS Testing - (2+1)

Learning objectives

- To understand the Genetic purity of seeds is one of the most important basic quality characters as perSeedsAct1966.
- To acquire knowledge about Loss of genetic purity leads to varietal deterioration leads to elimination of variety from seed supply chain.
- To know about after establishment of PPV and FRA, varietal purity is assessed by using established DUS characters and guidelines.
- To understand the methods of genetic purity assessment and DUS characters is much essential to prevent variety deterioration as well as for protection of plant varieties.
- To impart knowledge on various methods of genetic purity assessment and DUS testing for protection of plant varieties.

Theory

Unit I; Genetic Purity and Grow Out Test

Genetic purity – importance – factors influencing genetic purity; genetic/cultivar purity test – objectives – principles –methods; laboratory tests – green house and field plot methods, grow –out test,seed and seedling growth tests; chemical and biochemical methods; anthocyanin pigmentation, secondary compounds, phenol, peroxidase and fluorescence tests – chromatography techniques.

Unit II; Varietal Identification

Electrophoretic analysis of proteins and isozymes; DNA finger printing methods – RAPD, AFLP, SSR, SNP and other markers; computer based machine vision technique and image analysis for varietal identification.

Unit III; UPOV and PPV and FR Act

Genesis of Plant Variety Protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions–GATT agreement in relation to plant variety protection; Protection of Plant Varieties and Farmer's Rights (PPVand FR) Act 2001 – objectives, salient features, farmer's rights, breeder's rights, researcher's rights – PPV and FRA Rules 2003.

Unit IV; DUS testing

Criteria for protection of new varieties of plants; Distinctness, Uniformity and Stability (DUS) testing – principles and procedures, guidelines, sample size, test duration, testing option; varieties of common knowledge–extant variety–essentially derived variety – collection of References samples – grouping of varieties – example varieties; types and categories of characters–recording observations on characteristics–colour characteristics.

Unit V; DUS Characteristics of crops

Assessment of DUS characters of major crops based on morphological, biochemical and molecular markers–rice, maize, wheat, barley, blackgram, greengram, redgram, cowpea, rajma, sunflower, groundnut, castor, mustard, tomato, brinjal, onion,potato, chilli, bhendi, cucurbits, cole crops, sugarcane, cotton, flower, fruit and treespecies; statistical procedure–computer software for DUS testing; guidelines for registration of germplasm–impact of plant variety protection on seed industry growth.

Practicals

Genetic purity assessment based on seed characters- seedling growth tests, anthocyanin pigmentation-secondary compounds, Electrophoretic analysis of seed protein and isozymes - DNA finger printing- DUS testing based on morphological descriptors of plant –rice and millets – pulses and oilseeds – vegetable crops -flower, fruit and tree species – Recording observations and interpretation of data-Tree method of

classification of varieties / cultivars –Chemical and biochemical test applicable for DUS testing –statistical analysis and interpretation in major agricultural crops –major horticultural crops-Visit to DUS test centers.

Lesson plan

Theory lecture schedule

1. Genetic purity – importance
2. Factors influencing genetic purity
3. Genetic/cultivar purity test, objectives principles – methods; laboratory tests
4. Green house and field plot methods, grow–out test
5. Seed and seedling growth tests, chemical and biochemical methods
6. Anthocyanin pigmentation, secondary compounds, phenol, peroxidase and fluorescence tests
7. Chromatography techniques, Electrophoretic analysis of proteins and isozymes
8. DNA finger printing methods –RAPD, AFLP, SSR, SNP and other markers
9. Computer based machine vision technique and image analysis for varietal identification.
10. Genesis of plant variety protection (PVP)
11. International union for protection of new varieties of plants (UPOV) and its functions
12. GATT agreement in relation to plant variety protection
13. Protection of plant varieties and farmer's rights (PPV and FRA) Act 2001 – objectives, salient features, farmer's rights, breeder's rights, researcher's rights
14. PPVandFRArules,2003
15. Criteria for protection of new varieties of plants
16. Distinctness, uniformity and stability (DUS) testing
17. **First test**
18. Principles and procedures, guidelines, sample size, test duration, testing option
19. Varieties of common knowledge
20. Extant variety – essentially derived variety - collection of References samples
21. Grouping of varieties – example varieties
22. Types and categories of characters–recording observations on characteristics
23. Assessment of DUS characters of major crops based on morphological, biochemical and molecular markers–rice and maize
24. Assessment of DUS characters in wheat and barley
25. Assessment of DUS characters in blackgram, greengram and redgram
26. Assessment of DUS characters in cowpea and rajma
27. Assessment of DUS characters in sunflower, groundnut, castor and mustard
28. Assessment of DUS characters in tomato, brinjal, onion and potato
29. Assessment of DUS characters in chilli, bhendi, cucurbits and cole crops
30. Assessment of DUS characters in sugarcane and cotton
31. Assessment of DUS characters in flower, fruit and tree species
32. Statistical procedure–computer software for DUS testing
33. Guidelines for registration of germplasm
34. Impact of plant variety protection on seed industry growth

Practical schedule

1. Genetic purity assessment based on seed characters
2. Genetic purity assessment based on seedling growth tests, anthocyanin pigmentation
3. Genetic purity assessment based on secondary compounds, phenol, peroxidase and fluorescence tests
4. Chromatography analysis of secondary compounds
5. Electrophoretic analysis of seed protein and isozymes
6. DNA fingerprinting using PCR techniques

7. DUS testing based on morphological descriptors of plant - rice and millets
8. DUS testing based on morphological descriptors of plant - pulses and oil seeds
9. DUS testing based on morphological descriptors of plant vegetable crops
10. DUS testing based on morphological descriptors of plant - flower, fruit and tree species
11. Recording observations and interpretation of data
12. Tree method of classification of varieties/cultivars
13. Chemical and biochemical test applicable for DUS testing
14. Practical eXercise on recording DUS characteristics, statistical analysis and interpretation in major agricultural crops
15. Practical eXercise on recording DUS characteristics, statistical analysis and interpretation in major horticultural crops
16. Visit to DUS test centers.
17. **Final Practical Examination.**

Course outcome

CO1: To acquire knowledge on geniuses of cultivars and grow out test.

CO2: Students will be able to understand molecular characterization of crops.

CO3: To understand the concept of seed legislation.

CO4: To understand the concept of DUS testing and characterization.

CO5: To understand DUS characterization of crops

CO-PO Mapping matrix

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

References

1.Anon. 2016. Manual of Seed Certification Procedures. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

2. ChakrabarthiSK.2010.SeedProductionandQualityControl.KalyaniPublishers,NewDelhi.

3.ChoudharyDR.2009.GuidelinesforStorageandMaintenanceofRegisteredPlantVarietiesin theNationalGeneBank.PublishedbyProtectionofPlantVarietiesandFarmer'sRightsAuthority. MinistryofAgriculture,GoI,NewDelhi,India.

4. ISTA.2010.HandbookofVarietyTesting.InternationalSeedTestingAssociation,Switzerland.

5.Joshi AK and Singh BD. 2004. Seed Science and Technology, Kalyani Publishers, NewDelhi, India.

6. Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios., Jodhpur, India.

7. Mishra DK, Khare D, Bhale, MS and Koutu GK. 2011. Hand book of Seed Certification. Agrobios, Jodhpur, Rajasthan.

8. Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. Seed Legislation in India. Agro bios, Jodhpur, Rajasthan.

9. Trivedi PC ,2011.SeedTechnologyandQualityControl.Publications,Jaipur,Rajasthan.

10.Sen S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

e-resources

1. https://books.google.co.in/books?isbn=16118603932.

2. https://books.google.co.in/books?isbn=81894220303
3. https://upov.int/test_guidelines/en/
4. http://plantauthority.gov.in/crop guidelines.html
5. https://upov.int/resource/en/dus_guidance.html

SST 605 - SEED VIGOUR AND CROP PRODUCTIVITY - (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 fielde mergence 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
8. Types of vigour test – direct and indirect tests
9. **First test**
10. Physical, Physiological and Stress test for vigour.
11. Chemical and biochemical test for seed vigour
12. Enzyme test for seed vigour - 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

CO-PO Mapping matrix

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

References

1. Agrawal PK and Dadlani M. 1992. Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications.

2. Bewley J and Black M. 1994. Physiology of Development and Germination. Springerlink, New York.

3. Chakrabarthi SK. 2010. Seed Production and Quality Control. Published by Kalyani Publisher., New Delhi, India

4. Chalam GV, Singh A and Douglas JE. 1967. Seed Testing Manual. ICAR and United States Agency for International Development, New Delhi.

5. David R Murray. 1985. Seed Physiology. Saunders College Publishing/ Har court Brac.

6. International Seed Testing Association. 2018. Handbook on Seedling Evaluation, 4th Edition, Published by ISTA, Zurichstr, Switzerland.

7. ISTA. 1999. Seed Science and Technology, 27th supplement.

8. Khan AA. 1977. The Physiology and Biochemistry of Seed Dormancy and Germination. North–Holland Publishing Company, USA.

9. Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi, India.

10.Maiti RK, Sarkar NC and Singh VP. 2006. Principles of post harvest seed physiology and technology. Agrobios., Jodhpur, India.

e-resources

1. https://link.springer.com/chapter/10.1007/978-94-009-2764-3_71

2. https://link.springer.com/chapter/10.1007/978-1-4684-7747-4_8

3. https://link.springer.com/chapter/10.1007/978-1-4615-1783-2_7

4. https://doi.org/10.1079/9780851993959.0073

5. https://researchgate.net/publication/326255175_Seed_Vigour_Testing_Principle_and_Methods

SST 606 – Advances in seed science - (2+0)

Learning objectives

- To learn about seeds from its development to storage
- To understand concepts of physiological and molecular aspects of seed development
- To evaluate the quality seeds from seed quality enhancement techniques
- To recognize the Modern techniques for varietal identification
- To acquire a knowledge of recent advances in seed science

Theory

Unit I; Physiological and molecular expression in seeds during development

Physiological and molecular aspects of seed development – gene eXpression during seed development – selective elimination of cells – theories and concepts; physiological and molecular regulation of germination and dormancy; desiccation and stress tolerance – gene expression– mechanism – structural changes in membranes of developing seeds; prediction of seed dormancy and seed longevity using mathematical models; climate change effects on pollination, seed formation, development and quality.

Unit II; Novel approaches on seed growth

Recent techniques in seed production of self incompatible, protogyny, protandry and apomictic plant species – Gene Use Restriction Technology (GURT) – terminator and verminator technology – Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) *Cas* – gene editing; seed proteomics – principles, methods, applications in seed science- genetic analysis and QTL mapping of traits related toseed vigour, ageing and longevity – OMICS in related to seed science and technology; somatic embryogenesis – principles and methods of production of synthetic/ somatic seeds – merits and demerits.

Uni III; Modern techniques for varietal identification

Modern techniques for identification of varieties and hybrids – principles and procedures; DNA fingerprinting and other molecular techniques and their utilization – GM seeds and their detection techniques; Use of machine vision and image analysis techniques for varietal identification. Application of artificial intelligence (AI) and machine learning (ML) and virtual reality (VR) in seed science.

Uni I V; New concepts about seed quality enhancement

Recent accomplishments in seed enhancement research – seed coating, pelleting and priming techniques – physiological, molecular and sub-cellular basis of seed priming – detection and identification of seed borne diseases and insect pests through advanced techniques – ELISA and PCR based techniques.

Unit V; Seed movement and ethics

International movement of seeds – OECD seed certification schemes – recent developments in seed laws and policies – ethical issues and IPR system related toseed trade and movement.

Lesson Plan

Theory lecture schedule

1. Physiological and molecular aspects of seed development
2. Gene expression during seed development – selective elimination of cells – theories and concepts;
3. Physiological and molecular regulation of germination and dormancy
4. Desiccation and stresstolerance during seed development
5. Gene eXpression – mechanism of desiccation and stress tolerance
6. Structural changes in membranes of developing seeds during dessication & stress tolerance

7. Prediction of seed dormancy and seed longevity using mathematical models
8. Effects of climate change on pollination, seed formation,
9. Environmental impact on seed development and quality.
10. Recent techniques in seed production of self- incompatible, protogyny, protandry and apomictic plant species
11. Gene Use Restriction Technology (GURT)
12. Seed terminator and verminator technology
13. Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) *Cas* – gene editing
14. Seed proteomics – principles, methods, applications in seed science
15. Genetic analysis and QTL mapping of traits related to seed vigour, ageing and longevity
16. OMICS in related to seed science and technology
17. **First test**
18. Somatic embryogenesis – principles and methods of production of synthetic/ somatic seeds – merits and demerits.
19. Modern techniques for identification of varieties and hybrids – principles and procedures
20. DNA fingerprinting and other molecular techniques and their utilization
21. GM seeds and their detection techniques
22. Use of machine vision and image analysis techniques for varietal identification.
23. Application of artificial intelligence (AI)
24. Uses of machine learning (ML)
25. Virtual reality (VR) in seed science.
26. Recent accomplishments in seed enhancement research – seed coating
27. Recent accomplishments in seed enhancement research – seed pelleting
28. Seed priming techniques – physiological basis of seed priming
29. Seed priming techniques – molecular and sub-cellular basis of seed priming
30. Detection and identification of seed borne diseases through advanced techniques – ELISA and PCR
31. Detection and identification of insect pests through advanced techniques – ELISA and PCR
32. International movement of seeds – OECD seed certification schemes
33. recent developments in seed laws and policies – ethical issues
34. IPR system related toseed trade and movement.

Course outcomes

CO 1: Gain knowledge about seed physiological, biochemical and environmental changes.
CO2: Students can understand the genetic concepts on seed developments and maturation.
CO3: After this course students will have ideology about molecular works on varietal identification
CO 4: Better understanding and knowledge about principles and mechanism of recent advanced enhancement techniques pertaining to seed quality and their related research on field performance.
CO 5: Better understanding for international seed movement and IPR procedures

CO-PO Mapping matrix

		PO1	PO2	PO3	PO4	PO5

CO1		**1**	**-**	**-**	**-**	**3**
CO2		**1**	**-**	**-**	**-**	**-**
CO3		**-**	**-**	**1**	**1**	**-**
CO4		**-**	**-**	**-**	**-**	**-**
CO5		**-**	**-**	**3**	**-**	**-**

References

1. Baskin C and Baskin JM. 2014. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, Cambridge, UK.

2. Benech-Arnold R and Rodolfo S. 2004. *Handbook of Seed Physiology: Applications to Agriculture*. CRC Press., Florida, United States.

3. Bewley JD and Black M. 1994. *Seeds: Physiology of Development and Germination*. Springer, New York, USA.

4. Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. *Seeds: Physiology ofDevelopment, Germination and Dormancy*. Springer, New York.

5. Black M and Bewley JD. 2000. *Seed Technology and its Biological Basis*. CRC Press. Florida, United States.

6. David R Murray. 1985. *Seed Physiology*. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.

7. Figeys D. 2005. Industrial Proteomics: Applications for Biotechnology and Pharmaceuticals (No. TP248. 65. P76 I535 2005). United States.

8. Kozlowski TT. 2012. *Seed Biology: Importance, Development and Germination*. (Vol. I). Academic Press Inc., New York.

9. Lombardo L. 2014. Genetic Use Restriction Technologies: a review. *Plant biotechnology journal*. **12**(8): 995-1005.

10.Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.

e–resources

1. https://springer.com/gp/book/9783540574484
2. https://synthego.com/resources/crispr-101-ebook
3. https://link.springer.com/book/10.1007/978-981-13-0032-5
4. https://springer.com/gp/book/9780306447471#aboutBook
5. https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13

SST 607 Advances in Seed Quality Enhancement - (1+1)

Learning objectives

- To impart knowledge on seed quality enhancement techniques and their associated quality changes in seed.
- Equip the students with highly insightful and key importance on seed quality enhancement
- To acquire knowledge about germination related problems and prompts market value of **seeds**.
- To know about the role of Seed enhancement technologies in ecological restoration.
- To Understand the principles and mechanisms involved in seed quality improvement would enable to modulate the performance of seed in field

Theory

Unit I; Seed quality enhancement Introduction

Seed quality – importance and enhancement – principles, concept, significance, strategies; types of seed enhancement – physical, physiological and biological enhancement techniques

Unit II; Physical seed quality enhancement

Physical seed quality enhancement – concept and principles of grading – upgrading – magnetic, electromagnetic, irradiation, coating, pelleting, colouring; plasma treatment – thermal and cold plasma – treatment; application of nano formulations – concepts – principles – mode of action on improving germination

Unit III; Physiological seed quality enhancement

Physiological methods of seed quality enhancement – seed priming – principles, methods, mode of action – physiological, biochemical and molecular mechanism of priming techniques; seed infusion – principles and methods, mode of action – imparting abiotic stress tolerance – hardening – principles and methods

Unit IV; Biological formulations

Application of biological formulations – bacterial, fungal agents – concepts, formulations and compatibility; methods of application – growth promotion – protection – control over pest and disease infection and mode of action; designer/ smart seed – concept, methods, applicability to different crops

Unit V; Storage enhancement techniques

Effect of different treatments on crop establishment and modulation of seedling growth – crop geometry, phenology and yield improvement; storability of primed, coated and pelleted seeds – pre-storage and mid-storage enhancement techniques – hydration-dehydration techniques, moisture equilibrium drying and halogenations – principles, methods and application

Practicals

Physical seed quality up gradation – specific gravity separator, density grading, floatation technique - seed pelleting – methods of pelleting for different crop species - seed coating – polymer, colouring and nano emulsion coating - Effect of magnetic and electromagnetic seed treatment on seed germination and vigour - Seed priming – hydro, osmo, halo and solid matrix priming methods; Nutrient - bio priming - assessing the performance of primed seeds - Storability of primed seed - Seed hardening on the performance of seed under abiotic stress - Designer/ smart seed for different crops - Biological seed treatment, biological formulations - Effect of biological seed treatment on seedling growth and disease incidence - Microbial population in biologically treated seeds - Storability and vigour potential of treated seeds - mid-storage seed treatment – hydration-dehydration, moisture equilibrium and drying - Halogenation of seeds and their effect on seed performances - Performance of treated seeds under field condition

Lesson Plan

Theory lecture schedule

1. **P**rinciples, concept, significance, strategies and importance of Seed quality and enhancement
2. Types of seed enhancement physical, physiological and biological enhancement techniques
3. Physical seed quality enhancement, concept and principles of coating, pelleting and colouring
4. Concepts and principles of grading and upgrading by magnetic, electromagnetic and irradiation
5. Plasma treatment thermal and cold plasma treatment
6. Concepts, principle and application of Nano formulations - mode of action on improving germination

7. physiological seed quality enhancement Mode of action, principles and methods of physiological seed quality enhancement
8. Physiological, biochemical and molecular mechanism of priming techniques
9. **First test**
10. Principles and methods of imparting abiotic stress tolerance, hardening, Principles, methods and mode of action of seed infusion
11. Concepts, formulations, compatibility and methods of application of biological formulations bacterial, fungal agents
12. Growth promotion, protection and control over pest and disease infection and mode of action
13. Concept, methods and applicability of designer/ smart seed to different crops
14. Effect of different treatments on crop establishment and modulation of seedling growth, crop geometry, phenology and yield improvement
15. Storability of primed, coated and pelleted seeds
16. Pre-storage and mid-storage enhancement techniques
17. Principles, methods and application of hydration-dehydration techniques, moisture equilibrium drying and halogenations

Practical schedule

1. Physical seed quality up gradation – specific gravity separator, density grading, floatation technique
2. Practicing seed pelleting – methods of pelleting for different crop species
3. Performing seed coating – polymer, colouring and nano emulsion coating
4. Study on the effect of magnetic and electromagnetic seed treatment on seed germination and vigour
5. Practicing seed priming – hydro, osmo, halo and solid matrix priming methods
6. Nutrient and bio priming and assessing the performance of primed seeds
7. Assessing the storability of primed seed
8. Study on seed hardening on the performance of seed under abiotic stress
9. Preparation of designer/ smart seed for different crops
10. Biological seed treatment – biological formulations, bacteria, fungi, protectants and bio fertilizers
11. Study on the effect of biological seed treatment on seedling growth and disease incidence;
12. Estimating the microbial population in biologically treated seeds
13. Assessing the storability and vigour potential of treated seeds
14. Performing mid-storage seed treatment – hydration-dehydration, moisture equilibrium and drying
15. Halogenation of seeds and their effect on seed performances
16. Assessing the performance of treated seeds under field condition
17. **Final Practical Examination**

Course outcomes:

CO1: Gain technical skills on seed quality enhancement techniques and their associated quality changes in seed.

CO2: Acquire knowledge of germination related problems and methods to overcome**.**

CO3: Understand the role of Seed enhancement technologies in ecological restoration.

CO4: Acquired insight about Seed coating and priming which can be used to improve the potential seed germination response

CO5: Inculcate knowledge about physical, physiological and biological seed enhancement treatments for a uniform stands and better yields.

CO-PO Mapping matrix

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

References

1. Bewley JD, Bradford KJ, Hilhorst HWM and Nonogaki H. 2013. *Seeds: Physiology of Development*, *Germination and Dormancy*, Third Edition. Springer, New York, United States.
2. Doijode SD. 2006. *Seed Quality in Vegetable Crops. In: Handbook of Seed Science and Technology*. Basra AS (Ed.). The Haworth Press, New York, United States. pp. 677–702.
3. Filatova I, Azharonok V, Lushkevich V, Zhukovsky A, Gadzhieva G, Spasic K, Zivkovic S, Puac N, Lazovic S, and Malovic G. 2013. *Plasma Seeds Treatment as a Promising Technique for Seed Germination Improvement*. 31st International Conference on Phenomena in Ionized Gases, Granada, Spain.
4. Glick BR. 2012. *Plant Growth-Promoting Bacteria: Mechanisms and Applications*. Hindawi Publishing Corporation, Scientifica.
5. Halmer P. 2003. 'Methods to improve seed performance.' In: Benech-Arnold RL, Sanchez RA (Eds.). *Seed Physiology, Applications to Agriculture*. Food Product Press, New York, United States.
6. Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios., Jodhpur, India.
7. McDonald MF and Copeland LO. 2012. *Seed Production: Principles and Practices*. Springer Science and Business Media., Boston, United States.
8. Thomas B, Murphy DJ and Murray BG. 2003. *Encyclopedia of Applied Plant Sciences* (3 volume set). Elsevier Science, Netherland.
9. Rakshit A and Singh HB. 2018. *Advances in Seed Priming*. Springer Nature Singapore Ltd., Singapore.
10. Redenbaugh K. 1993. *Synseeds: Application of Synthetic Seeds to Crop Improvement*. CRC Press, London, UK.

e-resources

1. http://seedres.in/
2. http://agritech.tnau.ac.in/
3. http://bioline.org.br/pdf?cj17015
4. https://seedtest.org/en/home.html
5. https://ncbi.nlm.nih.gov/pmc/articles/PMC4746480/

SST 608 GERMPLASM CONSERVATION TECHNIQUES - (1+1)

Learning objectives:

- To study about different germplasm conservation techniques
- To know about types of gene banks and their collections
- To study the cryopreservation and its procedure
- To study types of cryoprotectants used in cryopreservation
- To know about germplasm handling organizations

Theory

UNIT I; Basics of germplasm conservation

Biological diversity in India – importance – need for conservation – concept of natural reserves and gene banks; post-exploration handling of germplasm collections, preservation of seed and plant specimens, importance and use of herbaria; *in-situ* conservation – components – biosphere reserve – natural park; factors influencing conservation; *in-situ* c.onservation – national programmes – on farm conservation.

UNIT II; Ex-situ conservation and its components

Ex-situ conservation – components – plant genetic resources conservation in genebanks – national gene banks – gene repositories – seed gene bank – types of collections – base, active and working collections – *perma-frost* seed conservation – guidelines for sending seeds to gene bank; handling of orthodoX and recalcitrant seeds for conservation – clonal repositories.

UNIT III; In-vitro conservation and its techniques

Methods of *in-vitro* conservation – short, medium and long term, concept of active and base *in-vitro* gene bank; *in-vitro* storage – culture maintenance – problems and perspectives – gene bank maintenance for temperate and tropical fruit crops, spices, tubers, bulbs, medicinal and aromatic plants; conservation of embryos and ovules, meristem, cell/ suspension cultures – protoplast and callus cultures – pollen culture and micro propagation techniques – genetic stability under long term storage

UNIT IV; Cryopreservation

Cryopreservation – principle and method – handling of orthodoX and recalcitrant seeds for cryopreservation – cryoprotectants – desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation and dehydration techniques; application of cryopreservation techniques for agricultural, horticultural and forest crops.

UNIT V; Gene banks and their standards

Gene bank standards for various crops – monitoring viability of stored seed samples – multiplication and regeneration of stored germplasm materials – National and International organizations – NBPGR and NPGRI – roll and functions; Dooms-day safe seed vault – Biodiversity International – conservation guidelines.

Practicals

Study on *In-situ* conservation methods and case studies; Plant exploration, germplasm collection and documenting passport data ; *Ex-situ* conservation techniques for long term conservation of germplasm collections; Preparation and handling of materials, packaging and documentation ; Preparation of seed album and herbarium specimens for ex-situ conservation ; Planning and designing of cold storage units and facilities for gene bank ; Conservation protocols for orthodox seeds ; Study of conservation protocols for recalcitrant seeds ; Conservation techniques for vegetative propagules/ clones ; Cryopreservation techniques – encapsulation, dehydration, freezing, thawing methods ; Cryopreservation of *in-vitro* cultures – meristem, embryo, cell suspension andpollen cultures ; Study on freezing and vitrification techniques ; Conservation technique of forest tree species ; Study on *in-vitro* cryo-gene banking and database management ; Visit to national and regional seed gene banks ; Visit to on-farm conservation sites and Botanical Survey of India.

Lesson Plan

Theory lecture schedule

1. Biological diversity in India, its importance and need for conservation. Concept of

natural reserves and gene banks and post-exploration handling of germplasm collections.

2. Preservation of seed and plant specimens, importance and use of herbaria. *In-situ* conservation and its components biosphere reserve, natural park.

3. Factors influencing conservation *in-situ* conservation, national programmes and on farm conservation.

4. *Ex-situ* conservation, its components, plant genetic resources conservation in genebanks, national gene banks, gene repositories and seed gene bank.

5. Types of collections: base, active and working collections. *Perma-frost* seed conservation and guidelines for sending seeds to gene bank.

6. Handling of orthodox and recalcitrant seeds for conservation, clonal repositories. Methods of *in-vitro* conservation-short-medium- and long-term conservation.

7. Concept of active and base *in-vitro* gene bank. *In-vitro* storage and culture maintenance along with problems and perspectives.

8. Gene bank maintenance for temperate, tropical fruit crops, spices, tubers, bulbs, medicinal and aromatic plants.

9. First test

10. Conservation of embryos and ovules, conservation of meristem, cell/ suspension cultures. Protoplast and callus cultures, pollen culture and micro propagation techniques.

11. Genetic stability under long term storage. Cryopreservation, its principle and method of cryopreservation.

12. Handling of orthodox and recalcitrant seeds for cryopreservation, Cryo protectants, Desiccation, rapid freezing, slow freezing and vitrification techniques, encapsulation and dehydration techniques.

13. Application of cryopreservation techniques for agricultural crops, horticultural crops and forest crops.

14. Gene bank standards for various crops, Monitoring viability of stored seed samples.

15. Multiplication and regeneration of stored germplasm materials.

16. National and International organizations for germplasm storage, NBPGR and NPGRI, their role and functions.

17. Dooms-day safe seed vault, Biodiversity International and its conservation guidelines.

Course outcomes

CO 1: The scholars understand about the gene banks and the process of maintenance of different crops.

CO 2: Understand about ex-situ and in-situ conservation techniques and their working procedure and their importance.

CO 3: Gain knowledge about **c**ryopreservation technique for different crops.

CO 4: Scholars acquired scientific knowledge about planning and designing of cold storage units.

CO 5: Scholars understand about germplasm organizations and their guidelines.

CO-PO Mapping matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**

CO1	**2**	**-**	**-**	**3**	**2**
CO2	**-**	**-**	**3**	**-**	**-**
CO3	**-**	**-**	**2**	**-**	**2**
CO4	**-**	**-**	**-**	**-**	**-**
CO5	**-**	**-**	**2**	**-**	**-**

References:

1. Basra AS (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Product Press, USA.
2. Brush SB. 1999. *Genes in the field: On-farm Conservation of Crop Diversity*. Lewis Publishers, Boca Raton, Florida, USA.
3. Choudhary DR. 2009. *Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank*. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture and Farmers Welfare, GoI, New Delhi.
4. Gupta D. 2009. *Seeds: Their Conservation Principles and Practices*. Sathish Serial Publishing House. New Delhi.
5. Jarvis DI, Meyer L, Klemick H, Guarino L, Smale M, Brown AHD, Sadiki M and Sthapit B. 2000. *A Training Guide for In-situ Conservation On-farm*. Version 1. International Plant Genetic Resources Institute, Rome, Italy.
6. Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi.
7. McDonald MF and Copeland LO. 2012. *Seed Production: Principles and Practices*. Springer Science and Business Media., Boston, USA.
8. Meerabi G and Pullaiah T. 2015. *Plant Biodiversity Conservation and Management*, DayaPublishing House, Delhi.
9. Rao NK, Hanson J, Dulloo ME, Ghosh K, Nowell A and larinde M. 2006. *Manual ofSeed Handling in Genebanks*. Bioversity International, Rome.
10. Vernoy R, Shrestha P and Sthapit B. 2015. *Community Seed Banks: Origins, Evolution andProspects*, OXford, Routledge, UK.

e-resources:

- https://springer.com/gp/book/9783319225203
- https://onlinelibrary.wiley.com/doi/10.1002/9781118316467.ch4
- https://trove.nla.gov.au/work/10718000?q&versionId=12505038
- http://nbpgr.ernet.in/
- http://bioversityinternational.org

SST 609-Seed Ecology -(1+1)

Learning objectives

- To study the influence of ecology on seed production, reproductive biology, seed dispersal, longevity and adaptation mechanisms
- To study the effect of pollutants on seed production and quality.
- To identify the several adaptive mechanisms to escape from unfavorable environmental/ ecological situations.
- To study of underlying mechanisms and ecological significances of the seedsto carryout research as well as seed production
- This course also deals with the ecological strategies acquired by the seedfor successful perpetuation.

Theory

Unit I; Seed ecology

Introduction to ecology – seed ecology – importance – genetic effects – geographic adaptation of native and invasive species; ecological factors on seed germination and regeneration; reproductive allocation – reproductive effort; flowering phenology, assessment of resource allocation – positional and azimuth influence on flowering and reproduction; influence of climate change on reproduction, seed formation, germination and dormancy.

Unit II; Seed dispersal

Seed dispersal – definition – modes of dispersal, dispersal dynamics, aerial seed dispersal, pre and post dispersal hazards, seed predators and ecological significance. Seed polymorphism – types, causes, consequences on seedling adaptation.

Unit III; Soil seed bank

Soil seed bank – definition – classification – soil seed bank dynamics. Thermodynamic models – population dynamics in soil seed bank – seed longevity and germination models in soil seed bank – weed seed ecology and longevity – long term experiments in buried seeds; ecological significance of seed dormancy and seed polymorphism.

Unit IV; Influence of environment on seed germination

Influence of environment on seed germination – allelopathy, temperature, light, moisture and gaseous environment – eco-physiological role in seed storage.

Unit V; Effect of pollutants

Effect of pollutants – air, water and soil pollutants on seed germination and seedling establishment – factors limiting seedling establishment – problemsoils and seed management techniques – climate change and seed production – management strategies to overcome the effect of climate change on seed production and germination.

Practicals

Understanding flowering phenology of different crop species; Study of seed dispersal mechanism of different crop species; Study on agents and distance of dispersal of different crop species; Studies on pre and post dispersal hazards ;Assessing the natural regeneration in relation to ecology; Assessing the problems related to natural regeneration; Experiment on naturally buried seeds – dormancy and longevity; Studies on effect of environmental factors on seed germination and dormancy; of seed polymorphism on germination and dormancy; Assessing the allelopathy effect on seed germination in crop species; Effect of soil pollutants on seed germination; Effect of air pollutants on germination of crop seeds; Effect of water pollutants on growth on seed quality; Seed management practices for polluted environment and climate change effects; Visit to *in-situ* and *ex-situ* conservation sites.

Theory lecture schedules:

1. Introduction to ecology – seed ecology – importance, Genetic effects – geographic adaptation of native and invasive species,
2. Ecological factors on seed germination and regeneration, Reproductive allocation – reproductive effort; flowering phenology
3. Assessment of resource allocation –Positional and azimuth influence on flowering and reproduction, influence of climate change on reproduction, seed formation, germination and dormancy.
4. Seed dispersal – definition – modes of dispersal, dispersal dynamics, aerial seed dispersal.

5. Methods of seed dispersal-wind, animals, water and by explosion, Pre and Post dispersal hazards.
6. Seed polymorphism – types, causes, consequences on seedling adaptation, Seed predators and ecological significance.
7. Soil seed bank – definition – classification – soil seed bank dynamics. Thermodynamic models – population dynamics in soil seed bank.
8. Seed longevity and germination models in soil seed bank– weed seed ecology and longevity –long term experiments in buried seed
9. **First test**
10. **E**cological significance of seed dormancy and seed polymorphism
11. Influence of environment on seed germination – allelopathy, temperature and light
12. Influence of environment on seed germination - moisture and gaseous environment
13. Eco-physiological role in seed storage.
14. Effect of pollutants – air, water and soil pollutants on seed germination andseedling establishment
15. Factors limiting seedling establishment –Problem soils and seed management techniques
16. Climate change and seed production
17. Management strategies to overcome the effect of climate change on seed production andgermination.

Practical schedule

1. Understanding flowering phenology of different crop species
2. Study of seed dispersal mechanism of different crop species
3. Study on agents and distance of dispersal of different crop species
4. Studies on pre and post dispersal hazards
5. Assessing the natural regeneration in relation to ecology
6. Assessing the problems related to natural regeneration
7. Experiment on naturally buried seeds – dormancy and longevity
8. Studies on effect of environmental factors on seed germination and dormancy
9. Influence of seed polymorphism on germination and dormancy
10. Assessing the allelopathy effect on seed germination in crop species
11. Effect of soil pollutants on seed germination
12. Effect of air pollutants on germination of crop seeds
13. Effect of water pollutants on growth on seed quality
14. Seed management practices for polluted environment and climate change effects
15. Visit to *in-situ* and *ex-situ* conservation sites
16. To biological hotspots.
17. **Practical Examination**

Course outcomes

CO1: This course made the students to understand the problems in natural regeneration, storage and dormancy and to address these problems.

CO2: The students were understand the effect of pollutants on seed production and quality.

CO3: The students acquired knowledge about several adaptive mechanisms to escape from unfavorable environmental/ ecological situations.
CO4: The students understand the techniques on production of qualityseeds at different ecological conditions
CO5: Scholars learned about ecological strategies acquired by the seed for successful perpetuation.

CO-PO Mapping matrix

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

References

1. Baskin CC and Baskin JM. 1998. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Elsevier, Netherlands.
2. Fenner M and Ken Thompson. 2005. *The Ecology of Seeds*. Cambridge University Press, London,United Kingdom.
3. Heydecker W. (Ed.). 1985. *Seed Ecology*. Penn State University Press.
4. Kozolowski TT. 1972. *Seed Biology* Vol. II, Academic Press., New York and London.
5. Maiti RK, Sarkar NC and Singh VP. 2006 *Principles of Post Harvest SeedPhysiology and Technology*. Agrobios, Jodhpur, India.
6. Sinclair TR and Gardner FP. 1977. *Principles of Ecology in Plant Protection*. CAB International, Wallingford, United Kingdom.
7. Bewley, J.D., Bradford, K., Hilhorst, H., Nonogaki, H., 2013. *Physiologyof Development, Germination and Dormancy,* 3rd Edition. Springer-Verlag NewYork
8. Vanangamudi, K. 2014. *Seed Science and Technology* – An illustrated text book. New India Publishing Agency, New Delhi.
9. Copeland, L.O. & McDonald, M.B. 2001. *Principles of Seed Sciences and Technology*. 4 th Ed. Chapman & Hall, New York.
10. Brian A. Larkins and Indra K. Vasil, 2012, *Cellular and Molecular Biology of Plant Seed Development,* Springer Netherlands

e-resources
1.https://cabi.org
2.https://ncbi.nlm.nih.gov

3.https://link.springr.com
4.http://libgen.io/book/index.
5.http://libgen.io/book/index

SST 610 -Seed Planning, Trade and Marketing - (1+1)

Learning objectives

- To know the history, growth and role of seed industry in indian agriculture
- To impart knowledge on planning seed production programmes, national and international movement of seeds and marketing strategies
- To study the international
- seed trading policies and its related organizations
- To make a vision on the international and domestic seed demand, well-structured planning and marketing
- To address seed production, distribution and pricing strategies

Theory

UNIT I; Chronology and status of seed industry

Seed industry – genesis, history and growth – structure of seed industry in India – mission and objectives of seed Industry; status and role of seed industry in Indian agriculture

UNIT II; Seed production strategies

Seed production programmes – characters, types; planning and organizing seed programmes in public and private sectors – small, medium, large and more advanced seed programmes – local, national and international seed programmes; seed demand forecasting – purpose – methods and techniques – factors determining seed demand – seed multiplication ratio, seed replacement rate and variety replacement rate; seed production planning for varieties and hybrids – compact area approach and seed village – contractual seed production – custom seed production – public private partnership – transgenic seeds – demand assessment.

UNIT III; International seed trading policies and organizations

New seed policy – genesis – functions; WTO – Indian seed industry – patenting and *suigeneris* system – The Seeds Bill, 2004 and 2011; role and contributions of MNC's in seed trade in India; International trade of seeds – government policies – International organizations involved in seed movement and trade – International Seed Federation (ISF), ISTA – OECD seed schemes – operational guidelines; import and eXport of seeds – EXim policies – guidelines and salient features; seed production and quality control systems in SAARC Nations and other developed countries; quarantine measures – procedures, guidelines and certificates in international seed movement and trade.

UNIT IV; Seed production and marketing tactics

Seed production and distribution system in central and state governments, co-operative and private organizations – seed marketing – definition, concept, importance and type of markets – domestic and global market – problems and perspectives; marketing polices – seed marketing schemes, marketing channels – responsibilitiesof dealers – marketing mix; handling and management of sales return seed stocks.

UNIT V; Marketing skills and risk management

Seed pricing – local market rate – factors affecting prices and pricing policies – fixation of procurement and sale price of seeds – cost analysis – seed market intelligence – marketing promotional activities; seed supply chain management – missing

link – risk and management.

Practicals

Data collection on status of Indian and global seed industry; Planning seed programmes for varieties and hybrids; custom seed production and contractual seed production ; Planning for establishment of small and medium seed enterprises; Planning for establishment of large scale seed enterprises; Assessment of seed demand – demand forecasting methods; Assessment of seed multiplication ratio, seed replacement rate and variety replacement rates for different crops; Study on the economics of seed production and marketing; exercise on fixing procurement and sale price of seeds; Study of seed marketing channels – survey and interaction with seed dealers and distributors; Visit to plant quarantine station and study of quarantine requirements and certificates for domestic and international seed trade; Visit to modern seed processing unit, advanced seed storage complex and interactions; Visits to state seed corporations, Visit to MNCs and expert discussion Case studies and SWOT analysis; Planning for establishment of new seed ventures and project preparations;

Lesson plan

Theory lecture schedule

1. History and growth of seed industry
2. Mission and objectives; status and role of seed industry in Indian agriculture
3. Seed production programmes in public and private sectors
4. Seed demand forecasting purpose, methods and techniques
5. Seed multiplication ratio, seed replacement rate and variety replacement rate;
6. Seed production planning for varieties and hybrids
7. Contractual and custom seed production; public private partnership
8. Seed policy- Patenting and *suigeneris* system
9. **First test**
10. International organizations and EXim policies involved in seed movement and trade
11. Seed production and quality control systems
12. Quarantine measures procedures, guidelines and certificates
13. Seed production and distribution system
14. Seed marketing concepts, types, problems and perspectives
15. Marketing channels and marketing miX
16. Seed pricing, pricing policies and cost analysis
17. Seed market intelligence supply chain management and risks

Practical schedule

1. Data collection on status of Indian and global seed industry
2. Planning seed programmes for varieties and hybrids
3. custom seed production and contractual seed production
4. Planning for establishment of small and medium seed enterprises
5. Planning for establishment of large scale seed enterprises
6. Assessment of seed demand – demand forecasting methods
7. Assessment of seed multiplication ratio, seed replacement rate and variety replacement rates for different crops
8. Study on the economics of seed production and marketing
9. Exercise on fixing procurement and sale price of seeds
10. Study of seed marketing channels – survey and interaction with seed dealers and distributors
11. Visit to plant quarantine station and study of quarantine requirements and certificates for domestic and international seed trade
12. Visit to modern seed processing unit
13. Advanced seed storage complex and interactions

14. Visit to state seed corporations,
15. Visit to MNCs and expert discussion Case studies and SWOT analysis
16. Planning for establishment of new seed ventures and project preparations
17. Final Practical Examination

Course outcomes

CO 1: This course enables the students in knowing the seed industry in India and its objectives.
CO 2: Students will be able to forecast the seed demand and produce the seeds using the public-private partnership.
CO 3: By knowing all the seed Act and Laws, students are made aware of the quality standards and quarantine measures by various countries.
CO 4: The student comes to know about the seed production and distribution in public and private organizations.
CO 5: Marketing of seeds, price, supply chain and risks involved in marketing is known.

CO-PO Mapping matrix

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

References

1. *Acharya SS and Agarwal NL. 2004. Agricultural Marketing in India, 4th Ed. OXford and IBH. Agrawal RL. 1996. Seed Technology. OXford, IBH Publishing Co., New Delhi, India.*
2. *Broadway AC and Broadway A. 2003. A Text Book of Agri-business Management.*
3. *Dadheech PK. 1996. Seed Programming, Management System and Concepts. Lok Sahitna Kendra, Jodhpur.*
4. *Feistrizer P and Fenwickkelly A. 1978. Improved Seed Production. FAO, Rome, Italy. Gurudev Singh and Asokan SR. 1997. Management of Seed Production Activity. OXford and*
5. *IBH Publishing Co., New Delhi, India.*
6. *Joshi AK and Singh BD. 2004. Seed Science and Technology. Kalyani Publishers, New Delhi, India.*
7. *Kalyani Singh AK and Pandey S. 2005. Rural Marketing. New Age Publications. Krishnasamy V, Ponnuswamy AS, Balamurugan P, Srimathi P, Natarajan N and Raveendran*
8. *TS. 2004. Compendium on Seed Science and Technology. Directorate of Publications, Tamil Nadu Agricultural University, Coimbatore, India.*
9. *Kugbei S. 2008. Seed Economics. Scientific Publishers, Jodhpur.*
10. *Singh G and Asokan SR. 1992. Seed Replacement Rate: Some Methodological Issues. Indian Institute of Management, Ahmedabad, India.*

e-resources

1. http://gov.mb.ca
2. http://agricoop.nic.in
3. http://agri.nic.in
4. https://sathguru.com/seed/
5. http://fao.org/3/V4450E/V4450E03.html

SST 611- 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.

Lesson plan

Theory lecture schedule

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. DNA markers
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: Fiber crops
48. Case studies: Plantation crops
49. Case studies: Forage crops
50. Case studies: Tuber crops and Medicinal Plants.

Course outcomes

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		

References

1. Hancock J.F. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.
2. Ladizinsky G.1999. Evolution and Domestication. Springer.
3. Miller A.J.2007. Crop Plants: Evolution. John Wiley & Sons.
4. Smartt J and Simmonds N.W. 1995. Evolution of Crop Plants. Blackwell.
5. L.T. Evans. 1996. Crop evolution, Adaptation and Yield. Cambridge Univ. Press.
6. M.R. Vasant. 2010. Plant Evolution and the Origin of Crop Species. Scitus Academics LLC
7. N. Arumugam. 2012. Evolution. Saras Publication.
8. James F. Hancock. 2012. Plant Evolution and the Origin of Crop Species. 3rd Ed. CABI
9. C. Wayne Smith. 2013. Crop Production - Evolution, History and Technology. Wiley India Pvt Ltd
10. Paroda RS and Arora RK.1991. *Plant Genetic resource Conservation and management*, NBPGR, New-Delhi

e- resources

1. *M.Ehsan Dulloo*.2021.Plant genetic resourcewA review of current research and future needs.Burleigh Dodds Science Publishing .DOI. https://doi.org/10.1201/9781003180623
2. Roberto Tuberosa , Andreas Graner and Emile Frison.Genomics of Plant Genetic Resources.Volume 1. Managing, sequencing and mining genetic resources. https://doi.org/10.1007/978-94-007-7572-5
3. Andreas W. Ebert and Johannes M. M. Engels.2021.Plant Biodiversity and Genetic Resources.published in *Plants.* https://doi.org/10.3390/books978-3-0365-0895-5. © by the authors
4. https://edisciplinas.usp.br/pluginfile.php/4869684/course/section/5880809/Hancock%20J.F.%20-.pdf
5. https://pba.ucdavis.edu/files/157972.pdf

SST 612 - Commercial Plant Tissue Culture - (2+0)

Learning objectives

- To provide awareness in 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.

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; bio reactors; synthetic seeds; management and marketing.

Unit II; Secondary production techniques

Production of useful compounds via, bio transformation 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 tissue culture-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.
Visit 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. Synthetic seeds using cotyledonary somatic embryos
11. What are biotransformation
12. Principle of Suspension cultures
13. Mechanism of Immobilization
14. Secondary metabolite through callus –suspension culture
15. Production of useful compounds by using biotransformation.
16. Production of useful compounds by using secondary metabolite.
17. **First test**
18. Production of useful compounds by using immobilization.
19. Examples of chemicals being produced for use in pharmacy and medicine
20. Examples of chemicals being produced for use in industry.
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

References

1. Honda,H.,Liu,C.,Kobayashi,T.2001.Large-ScalePlantMicropropagation.In:
2. ZhongJ.J.et al. (eds) Plant Cells. Advances in Biochemical Engineering/ Biotechnology, vol 72. Springer,Berlin,Heidelberg.
3. Bhojwani SS and Razdan MK.1986. Planttissueculture: theoryandpractice (Vol.5).Elsevier.
4. Varshney RK and Tuberosa R. 2007. Genomics-Assisted Crop Improvement. Springer,Dordrecht, vol.
5. Robert, N. T. and Dennis, J.G. (2000). Plant tissue culture concepts and laboratory exercises. 2" Ed. Florida: CRC Press.
6. BhojwaniSS.1983.*PlantTissueCulture:TheoryandPractice*.Elsevier
7. Gamborg OL and. Philips GC. 1995. Plant Cell, Tissue and organ culture.Fundamental Methods,NarosaPublishingHouse,NewDelhi.
8. PotrykusFandSpangenberg.1995.GeneTransfertoPlants,SpringarVerlag,Germany.
9. BrownTA.2010.GeneCloningandDNAAnalysis:AnIntroduction,6thEdition,Blackwellpublications,USA.
10. ChristouP&KleeH.2004.*HandbookofPlantBiotechnology*.JohnWiley&Sons.

e-resources

1. https://agrimoon.com/wp-content/uploads/Principles-of-Plant-Biotechnology.pdf.
2. https://intechopen.com/chapters/40187
3. https://orbitbiotech.com/plant-tissue-culture/
4. https://dbtncstcp.nic.in/Portals/0/Images/Plant-Tissue-Culture.-Techno-Commercial-Feasibility.pdf
5. https://isaaa.org/resources/publications/pocketk/14/default.asp

COM 601 ADVANCES IN COMPUTING APPLICATIONS (1+1)

Course Objective

- 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

Suggested Reading

1. Introduction to Latex by Tobias Oetiker
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

1. https://www.overleaf.com/learn/latex/Bibliography_management_with_bibtex
2. https://en.wikibooks.org/wiki/LaTeX/Bibliography_Management.
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)

Course 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.

Practical

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

sampling, Determination of sample size, Exercises on Inverse sampling, Stratified sampling, Cluster sampling and Systematic sampling, Estimation using Ratio and regression estimators, Estimation using Multistage design and Double sampling.

Theory Lecture Schedule

1. Classification, tabulation and graphical representation of data.
2. Descriptive statistics.
3. Theory of probability. Random variable and mathematical expectation.
4. Box-plot. Probability distributions: Binomial, Poisson, Negative binomial.
5. Normal distributions and their applications.
6. Concept of sampling distribution: t, chi-square and F distributions.
7. Tests of significance based on normal, t, chi-square and F distributions.
8. Correlation, Rank correlation, Correlation ratio.
9. Intra-class correlation. Test of significance of correlation coefficient.
10. Coefficient of determination.
11. Path analysis.
12. Regression analysis.
13. Partial and multiple correlation and regression.
14. Estimation of parameters. Predicted values and residuals.
15. Introduction to multivariate analytical tools.
16. Test of hypothesis on means, Multivariate analysis of variance and covariance.
17. **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

Suggested Reading

1. Agarwal, B. L. 2003, Basic Statistics, New Age International. New Delhi.
2. Anderson, T.W. 1958. *An Introduction to Multivariate Statistical Analysis.* John Wiley, New Delhi.
3. Bansil, P.C. 2002. *Agrl. Statistics*. CBS Publishers. New Delhi.
4. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. 1994. *Time Series Analysis: Forecasting and Control*. Pearson Education, Delhi.
5. Campbell, R.A. 1974. *Statistics for Biologists.* Cambridge University Press. New York.
6. Cochran, W.G. and Cox, G.M. 1957. *Experimental Design.* John Wiley and Sons Inc. New York.
7. Das, M. N. and Giri, N.C. 1986. *Design and Analysis of Experiments.* New Age International. New Delhi
8. Federer, W.T. 2002. *Statistical Design and Analysis of Intercropping Experiments.* Springer-Verlag. New York
9. Gomez and Gomez. 1984. *Statistical procedure for Agrl. Research.* Wiley-interscience. New

York
10. Gupta, S.P. 2004, Statistical Methods, S. Chand and Sons. New Delhi. Singh R and Mangat N.S. 1996. *Elements of Survey Sampling*. Kluwer Academic Publishers.

****