PONDICHERRY UNIVERSITY
PUDUCHERRY – 605 014

6th PG BOARD OF STUDIES IN AGRICULTURAL SCIENCES

M.Sc. (Agri.) Genetics and Plant Breedin
REGULATIONS AND CURRICULUM

(Effective from 2022-23 batch onwards)

PANDITJAWAHARLAL NEHRU COLLEGE OF AGRICUL
AND RESEARCH INSTITUTE (PAJANCOA&RI)
(*A Government of Puducherry Institution*) KARAIKAL – 60

PONDICHERRY UNIVERSITY
PUDUCHERRY – 605 014

REGULATIONS AND
CURRICULAM
for
M.Sc. (Agriculture/Horticulture)

(Effective from 2022-23)

REGULATIONS

PONDICHERRY UNIVERSITY

POSTGRADUATE DEGREE PROGRAMME

(Agriculture/Horticulture)

SEMESTER SYSTEM – REGULATIONS

1. SYSTEM OF EDUCATION

1.1 The rules and regulations provided herein shall govern Masters degree programmes **[M.Sc. (Agri.) or M.Sc. (Hort.)]** offered by Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA&RI), Karaikal under Pondicherry University.

1.2 The duration of Master's programme is two academic years (4 semesters). The first year of study shall be the first and second semesters after admission. The second year of study shall be the third and fourth semesters.

2. COMMENCEMENT

These regulations shall come into force from the academic year **2022-23**

3. DEFINITIONS

3.1 **'PG Coordinator'** means a teacher of a department who has been nominated by the Head of the Department to coordinate the postgraduate programmes in the department. The coordinator looks after registration, time table preparation, regulation of credit load, maintenance of individual student's files, *etc*.,

3.2 **'Semester'** means a period consisting of 110 working days inclusive of the mid-semester and practical examinations but excluding the study holidays and final theory examinations.

3.3 **'Academic year'** means a period consisting of two consecutive semesters including the inter-semester break as announced by the Dean.

3.4 **'Curriculum'** is a group of courses and other specified requirements for the fulfillment of the postgraduate degree programme.

3.5 **'Curricula and syllabi'** refer to list of approved courses for postgraduate degree programmes wherein each course is identified with a three-letter code, a course number, outline of the syllabus, credit assigned and schedule of classes.

3.6 **'Course'** is a teaching unit of a discipline to be covered within a semester having a specific number and credits as detailed in the curricula and syllabi issued by the University.

3.7 **'Major Course'** means the subject of Department or discipline in which the student takes admission. Among the listed courses, the core courses compulsorily to be registered shall be given '*' mark.

3.8 **'Minor Course'** means the course closely related to a student's major subject.

3.9 **'Supporting Course'** means the course not related to the major course. It could be any course considered relevant for student's research work or necessary for building his/her overall competence.

3.10 '**Common course'** means a course which is compulsorily registered by the postgraduate student for the completion of postgraduate degree programme. The marks obtained by the student in a common course will also be taken into account for calculating OGPA.

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

3.11 **'A credit'** in theory means one hour of class room lecture and a credit in practical means two and half hours of laboratory or workshop or field work per week.

Explanation : A 1+1 course (2 credits) means 1 hour theory and 2.5 hours practical per week.
A 0+1 course (1 credit) means 2.5 hours practical per week
A 1+0 course (1 credit) means 1 hour theory per week

3.12 **'Credit Load'** of a student during a semester is the total number of credits of all the courses including common courses, that a student register during that particular semester.

3.13 **'Grade Point'** means the total marks in percentage obtained in a course divided by 10 and rounded to two decimals.

3.14 **'Credit Point' means** the grade point multiplied by the credit load of the course.

3.15 **'Overall Grade Point Average (OGPA)'** means the total credit point of the courses completed by the student divided by total credits of the courses studied. The OGPA is to be worked out by rounding to nearest two decimals.

3.16 **'Arrear examination'** is an examination written for the failed course by a student without undergoing regular classes in that course.

3.17 **'Transcript Card'** is the consolidated report of academic performance of a student issued by the University on completion of the curriculum fulfillment. The format of Transcript Card is furnished in *Annexure-1.*

4. POSTGRADUATE PROGRAMMES

The list of various postgraduate programmes offered in various dicipline of the College is as follows:

M.Sc. (Agri.) Agricultural Economics
M.Sc. (Agri.) Entomology
M.Sc. (Agri.) Agronomy
M.Sc. (Agri.) Genetics and Plant Breeding
M.Sc. (Agri.) Soil Science
M.Sc. (Hort.) Vegetable Science

5. ADMISSION

5.1 Eligibility for admission:

i. Candidates seeking admission to master degree programme should have a four year bachelor's degree from State Agricultural Universities (SAU) or from other universities recognized by UGC/ICAR.

ii. Candidate who has undergone the course credit system with an OGPA of 3.00 out of 4.00 or 7.00 out of 10.00 or 70 percent aggregate alone is eligible to apply for various Master's degree programmes in this Institute. **Whereas, for SC/ST/PWD candidates the said requirement is an OGPA of 2.50 out of 4.00 or 6.00 out of 10.00 or 60 per cent aggregate.** However, this will not apply to State Department nominees. Just a pass in the concerned degree is sufficient for them.

iii. Prescribed minimum qualification from a recognized University for admission to Master's degree programme:

Sl.No.	Discipline	Requirement for Master's Degree
1.	Agricultural Economics	B.Sc.(Ag./Hort./Agrl. Marketing and Cooperation/Forestry) or B.Sc.(Hons) Agriculture/Horticulture/ Agrl. Marketing and Cooperation/Forestry
2.	Agronomy	B.Sc. (Ag.) or B.Sc.(Hons) Agriculture
3.	Entomology	B.Sc.(Ag./Hort./Forestry/Sericulture) or B.Sc. (Hons) Agriculture/Horticulture/ Forestry / Sericulture
4.	Genetics and Plant Breeding	B.Sc.(Ag./Hort./Forestry) or B.Sc. (Hons) Agriculture/Horticulture/ Forestry or B.Tech. (Biotechnology)
5.	Soil Science	B.Sc.(Ag./Hort) or B.Sc. (Hons) Agriculture/Horticulture
6.	Horticulture (Vegetable Science)	

5.2 Method of selection:

i. Candidates shall be required to be present on the specified date for a written test at their own expenses. If selected, they should come prepared to pay fees and get admitted immediately.

ii. The students will be ranked based on total marks scored by them in the categories mentioned below

Category	Weightage of marks (%)
OGPA in Bachelor's degree programme	50
Entrance	50
Total	**100**

iii. Written test with objective type (multiple choices) questions in the specific subject will be of one and half hour duration. A minimum of 50% (25 marks) is must for considering the candidate for admission. However, in case of SC/ST candidates, a minimum of 40% (20 marks) is must for considering the candidate for admission into that category.

Note: If a SC/ST candidate seeks admission under other categories a minimum of 50% **(25 marks)** in entrance test is must

iv. Candidates applied for two subjects should write the examination for both subjects continuously for two hours.

v. Seats are reserved for candidates belonging to scheduled Castes/Scheduled Tribes/Other Backward Classes as per the norms of Government of Puducherry.

vi. Two seats of the total sanctioned strength, irrespective of the discipline, are reserved for the in-service candidates of Department of Agriculture and Farmers Welfare, Government of Puducherry.

6. LANGUAGE REQUIREMENT

The medium of instruction is English. The postgraduate students should have adequate knowledge in English to read, write and speak in English and able to prepare high quality research papers in English.

7. RESIDENTIAL REQUIREMENT

7.1 The minimum residential requirement for Masters' degree shall be two academic years (four semesters) and the course should be completed within the maximum period of **five academic years (ten semesters)** from the date of admission.

7.2 In case a student fails to complete the degree programme within the maximum duration of residential requirement (five years), his/her admission shall stand cancelled.

8. REGISTRATION

The list of courses offered to the student in each semester shall be sent by the Dean to the Controller of Examinations for Registration of examination as instructed by the University from time to time.

9. DISCONTINUANCE AND READMISSION

As per University Regulations.

10. ADVISORY COMMITTEE

10.1 Each Postgraduate student shall have an advisory committee to guide the student in carrying out the programme. Only recognized teachers are eligible for teaching PG courses and guiding thesis research.

10.2 **Chairman/Guide**:

i. The approved guides by the Dean of the college only can be the guide for the students.

ii. Every student shall have a Chairman of the Advisory Committee who will be from his/her major field of studies.

iii. The Head of the departments will allot the masters students among the recognized guides.

iv. A teacher should have a minimum of two years of service before retirement for

allotment of Master's students.

v. At any given time, a PG teacher shall not be a chairman of Advisory Committee (including Master's and Ph.D. programmes) for more than five students.

10.3 **Chairman/ Co-guide/ Member from other collaborating University/ Institute/ Organization:**

i. The University / Institute may enter into Memorandum of Understanding (MOU) with other Universities / Institutions / Organizations for conducting research.

ii. The proposed faculty member from the partnering institution can be allowed to act as Co-guide / Member of Student Advisory Committee

Note: In special cases the proposed faculty member from the partnering institution can be allowed to act as Chairperson.

10.4 **Members** :

i. The advisory committee shall comprise a Chairman and two members. One member shall be from the concerned department and another member shall be from other department or discipline related to field of thesis research. **Staff having UG teaching experience of four years or more may be included as the members of the Student Advisory Committee.**

ii. In thesis topics involving more of inter-disciplinary approach, the number of advisory committee members from other disciplines may be increased by one with prior approval of the Dean.

10.5 **Formation of advisory committee:**

i. For Master's Programme the advisory Committee Chairman and members will be in the cadre of Professors, Associate Professors and Assistant Professors having three years of experience.

ii. Only recognized teachers are eligible for teaching PG Courses and guiding thesis research.

iii. A proposal for the formation of the advisory committee (Form 1) of the student shall be forwarded by the Heads of the Department to the Dean for approval within one month from the commencement of the first semester.

10.6 **Changes in advisory committee:**

i. The proposal for changes in the advisory committee (Form 1a) is to be sent to the Dean for approval, if it is keenly felt that such changes are absolutely necessary. The reason for such change should be indicated.

ii. The changes may be effected immediately, when the existing members are transferred elsewhere or resigned or retired.

iii. If a guide goes abroad or within India for more than 6 months, to attend any training or on leave for more than six months, the Chairman of the Advisory Committee has to be changed immediately. The same conditions will apply to members also.

10.7 **Absence of member during qualifying/final viva-voce examination**:

i. Conducting qualifying and thesis final viva voce examination in the absence of

members is not allowed.

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

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

iv. In the absence of the Chairman of advisory committee, respective Heads of Departments should act as Co-Chairman with prior permission of Controller of Examinations.

10.8 **Duties and responsibilities of the advisory committee**:

i. Drawing the student's academic plan for postgraduate programme.

ii. Guidance throughout the programme of the student.

iii. Guiding the student in selecting a topic for thesis research and seminar.

iv. Evaluation of research and seminar credits.

v. Correction and finalization of thesis draft

vi. The members should meet together along with the student for all the above purposes and sign the appropriate documents.

11. PLAN OF COURSE WORK:

The student's plan for postgraduate course work (Form 2) drawn up by advisory committee shall be sent for the approval of the Dean before the commencement of the mid semester examination during the first semester.

12. PROGRAMME OF RESEARCH WORK

The proposal for research programme of the student, in the prescribed format (Form 3) and approved by the advisory committee, shall be sent for approval of the Dean before the end of the semester in which the research credits are registered for the first time or before taking up of the research work whichever is earlier.

13. CREDIT REQUIREMENTS

13.1 **Minimum credit requirement:** A postgraduate student should complete a minimum of 70 credits as detailed below for award of the Master's degree.

Details	Minimum Credits
Major courses	20
Minor courses	08
Supporting courses	06
Common courses*	05
Seminar	01
Research	30
TOTAL	**70**

* List of Common courses

Course code	Course Title	Credit hour
PGS 501	Library and information services	0+1
PGS 502	Technical writing and communication skills	0+1
PGS 503	Intellectual property and its management in agriculture	1+0
PGS 504	Basic Concepts in Laboratory techniques	0+1
PGS 505	Agricultural research, research ethics and rural development programmes	1+0

13.2 **Maximum credit load:** A postgraduate student can register a maximum of 22 credits per semester including common courses, seminar and research. However, research credits registered per semester should not exceed 15.

13.3 **Comprehensive qualifying examination and thesis:** A postgraduate student should successfully complete a comprehensive qualifying examination and thesis in the major field of study and submission of thesis thereon.

13.4 **Extra Credits:**

i. Over and above the prescribed minimum credit requirements, extra course credits up to a maximum of six can be registered for Master's programme.

ii. The extra credits registered will be accounted for calculation of OGPA.

14. ATTENDANCE REQUIREMENTS

14.1 i. A minimum of 80 per cent attendance separately in theory and practical of the concerned course is a must, failing which the student shall not be permitted to appear for both final theory and final practical examinations in the course concerned and grade 'E' (incomplete) will be awarded.

ii. If a student falls short of the required attendance to an extent of 10 per cent or less, the shortage may be condoned by the Dean on the recommendation of the Advisory Committee and the concerned Head of the Department, on the condition that such shortage in attendance was due to unavoidable circumstances (on medical grounds) and such absence was continuous.

14.2 The student securing 'E' grade in a course must re-register the course when offered again with the permission of the University.

14.3 **Calculation of Attendance**

a) THEORY:

i. Number of classes conducted for a course from the first instructional day as per the time table to the last theory class of that semester is to be construed as the total number of theory classes conducted by the course teacher.
ii. The mid-semester examinations are normally conducted during class hours.
iii. The attendance for mid semester examination shall be counted as a theory class for calculating attendance.

b) PRACTICAL:

i. Number of practical classes conducted for a course from the first instructional

day as per the time table to the last practical class of that semester is to be construed as the total number of practical classes conducted by the course teacher.

ii. The final practical examination will be conducted after the completion of 96 working days as per the schedule.

iii. The attendance for practical examination shall not be counted for calculating the attendance for practical.

14.4 For calculating 80 per cent attendance the number of instructional days may be calculated only from the date of joining of the student for first year first semester only.

14.5 The students failing to attend the classes / examinations on non-official ground will be treated as absent.

14.6 Students deputed for sports, cultural meets *etc*., with prior permission of the Dean of the college shall be given attendance for the period of absence. However, students under this category must have attended a minimum of 50 per cent classes in the total theory and practical classes conducted.

15. EVALUATION OF STUDENT'S PERFORMANCE

15.1 Distribution of marks:

i. 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. The weightage of Theory and Practical shall be in the ratio of 80:20 respectively.

ii. The student should secure a minimum of 50 per cent marks in theory as well as in practical with an aggregate of 70 per cent to secure a pass in a course.

iii. The student should secure a minimum of 50 per cent marks in the final theory examination conducted by the University for securing a pass in a course.

iv. In each course, examinations will be conducted for 100 marks as detailed below.

Examination	Courses with theory and practical	Courses with only theory	Courses with only practical
Mid Semester (Internal)	20	30	30
Term paper (Internal)	10	10	10
Final Theory (External)	50	60	--
Final Practical	20	--	60
TOTAL	100	100	100

15.2 Mid Semester Examination (Internal Assessment):

i. Writing the mid-semester examination is a pre-requisite for writing the final theory and final practical examinations.

ii. Student failing to write mid-semester examination(s), shall not be permitted to attend the classes further in the course(s) concerned and the student will be awarded 'E' grade.

iii. The mid-semester examinations shall be conducted for a duration of one hour and for 20 or 30 marks.

iv. The Head of the Department with the help of the concerned PG coordinator shall prepare and announce the schedule of mid-semester examinations.

v. The mid-semester examinations shall be conducted from the 56th working day of the semester.

vi. The mid-semester examination shall be conducted and evaluated internally by the concerned course teacher(s).

vii. The mid-semester examination mark list should be sent by the course teacher to the academic section of the college 10 days prior to the commencement of final practical examinations along with term paper mark.

15.3 **Missing Examination:**

i. Missing examination shall be permitted only for mid-semester examination in deserving cases on the recommendation of the course teacher/Chairman and Head of the department and on prior approval by the Dean.

ii. The missing tests are not allowed for final theory and final practical examinations.

iii. The student shall write, in advance, to the Dean through the Chairman, PG coordinator and Head of the Department stating the reason for missing the mid-semester examination(s). Based on the recommendation of the Chairman, PG coordinator and the Head of the Department, the Dean shall permit the student for missing the mid-semester examination(s).

iv. A student missing mid-semester examination(s) with the prior approval of the Dean shall be permitted to take up missing examination of the particular course, subject to payment of the prescribed missing examination fee for each missing mid-semester examination.

v. Students deputed for official programmes of the College/University are exempted from paying the fee for missing test.

vi. Such missing examinations should be completed outside the regular class hours within 15 working days after the respective examinations.

vii. Attendance will not be given for taking up missing examinations.

15.4 **Final Theory Examination:**

i. An examination schedule prepared by the Controller of Examination for the final theory examinations shall be the final. The schedule of examinations shall be adhered strictly.

ii. The duration of final theory examinations will be two and half hours for courses with theory and practical (50 marks) or three hours for courses with only theory (60 marks).

iii. The final theory examinations shall be conducted by the University. Evaluated by two examiner, one by internal and one by external. However, in case of Non-credit e-courses, the final theory examination shall be conducted internally by the course teacher.

iv. In the evaluation process, if deviation is more than 20 per cent between the first and second evaluator, the paper shall be referred to third examiner who shall also be an external examiner.

15.5 **Final Practical Examination:**

i. The Dean shall announce the commencement of final practical examinations. The Heads of the Departments shall prepare the schedule for practical examination.

ii. The final practical examinations shall be conducted after the completion of minimum of 96 working days.

iii. Submission of bonafide practical records certified by the Course Teacher is a pre-requisite for appearing in a practical examination failing which 'F' grade will be awarded.

iv. For conducting final practical examination in each course, an *external examiner* (faculty of the Department other than the course teacher) shall be nominated by the Dean and the course teacher will be the *internal examiner*.

v. In the event of external/internal examiner nominated for practical examination could not conduct the examination, then the Dean shall nominate an alternative examiner to conduct practical examination.

vi. The duration of final practical examination shall be two and half hours.

vii. The practical examinations shall be jointly conducted by the internal and external examiners with mutual co-operation.

viii. They shall evaluate the candidates appearing at the examination according to their performance and the Forms so prepared shall be signed by both the examiners.

ix. The practical examination marks should be communicated to the University/ uploaded in the university website within 10 days after conduct of examination duly signed by all the examiners and hard copy forwarded to the university thereon.

15.6 **Arrear examination:**

i. Arrear examination is permitted for the final theory and final practical examinations only.

ii. The students are permitted to write the arrear examinations as and when conducted by the University.

iii. A student is permitted to write the final theory and practical examinations only two times during 5 years duration excluding the regular final examination (Mid-semester marks and Term paper marks shall be retained as such).

iv. In the event of a student failing to secure pass in the two arrear examinations permitted, he/she has to re-register the course along with the juniors as and when the course(s) are offered with the permission of the University and on payment of the prescribed fees.

15.7 **Evaluation of course**:

i. Each course shall carry a maximum of 100 marks. The results of the course shall be indicated by the grade points ranging from 0 to 10.

ii. The total marks in percentage obtained by the student in a course shall be divided

by 10 and rounded to two decimal places to get the grade point.

iii. The minimum Grade Point to be secured for the successful completion of a course shall be 7.00.

iv. In case of courses with theory and practical, minimum of 50 per cent mark separately in theory and practical with an aggregate of 70 per cent is essential.

v. Securing a grade point less than 7.00 in a course will be treated as 'F' (Failed) and the Grade Point will be 0.00 for calculating the GPA/OGPA. The following symbols may be used

E - INCOMPLETE (Lack of 80 per cent Attendance/other reasons)
F - FAILED

15.8 **Question paper pattern for theory examinations** :

15.8.1 The question paper pattern for mid semester (internal) examinations are indicated below:

Part	**Type of question**	**Number of questions**	**Number of questions to be answered**	**Mark per question**	**Total marks**
Courses with theory and practical (1+1 or 2+1 courses) (20 Marks & 1 hour duration)					
A	Objective*	20	20	0.5	10
B	Definitions/Concepts	12	10	1.0	10
	TOTAL				**20**
Courses with only theory (1+0 or 2+0 courses) (30 Marks & 1½ hour duration)					
A	Objective*	30	30	0.5	15
B	Definitions/Concepts	18	15	1.0	15
	TOTAL				**30**
Courses with only practical (0+1 courses) (30 Marks & 1½ hour duration)					
A	Objective*	30	30	0.5	15
B	Definitions/Concepts	18	15	1.0	15
	TOTAL				**30**

* Questions should be Fill-up the blanks, Choose the best among four options, True / False or Match the following type with equal number of question in each type and one or two more questions in any one type if examination is conducted for 30 marks

15.8.2 The question paper pattern final theory (external) examinations are indicated below:

Part	Type of question	Number of questions	Number of questions to be answered	Mark per question	Total marks
Courses with theory and practical (1+1 or 2+1 courses) (50 Marks & 2.5 hours duration)					
A	Objective (MCQ's only)	20	20	0.5	10
B	Definitions/Concepts	12	10	1.0	10
C	Paragraph answers	7	5	2.0	10
D	Essay type answers (**EITHER OR** type) - One main question from each unit shall have one choice	5	5	4.0	20
	TOTAL				**50**
Courses with only theory (1+0 or 2+0 courses) Final Theory Examination (60 Marks & 3.0 hours duration)					
A	Objective (MCQ's only)	20	20	0.5	10
B	Definitions/Concepts	18	15	1.0	15
C	Paragraph answers	7	5	2.0	10
D	Essay type answers (**EITHER OR** type) - One main question from each unit shall have one choice.	5	5	5.0	25
	TOTAL				**60**

15.9 **Question paper pattern for final Practical Examination**: The following distribution of marks shall be adopted in conducting the final practical examinations.

Details	Courses with Theory and Practical	Courses with only Practical
Practical Field work / Lab Work / Written exam	20 (2.5 hrs)	60 (3 hrs)
Total	**20**	**60**

For conducting practical examinations, the type and number of questions can be decided by the concerned internal and external examiners. Choice may be given to the extent of 20 per cent under subjective type questions.

15.10 **Term Paper**:

i. Submission of a term paper by the students is a must.

ii. The term paper topics shall be assigned by the course teacher. Term papers should cover a wide range of subjects within the course limits.

iii. The term paper shall be evaluated by the course teacher.

15.11 **Return of evaluated answer papers**:

i. The evaluated answer papers of mid-semester shall be shown to the students after the examination. Discrepancies if any, in awarding marks, the student can approach the teacher concerned immediately for rectification.

ii. The answer paper should be retained by the course teacher for 6 months or declaration of results by Pondicherry University, whichever is earlier and then disposed off.

16. COMPREHENSIVE QUALIFYING EXAMINATION

16.1 i. Only those postgraduate students who successfully complete the comprehensive qualifying examination shall be admitted to candidacy of the degree.

ii. The qualifying examination consists of written and oral examination in major subjects only and the students should be allowed after completion of 80 per cent of total course credit load including major and minor courses.

iii. The qualifying examination shall be conducted only in the major courses as per the norms given below:

Question paper setting	-	External
Evaluation of answer book	-	External
Qualifying marks	-	60 per cent
Viva Voce	-	External
Grading	-	Satisfactory/Not Satisfactory

16.2 **Selection of examiner**:

i. The Head of the concerned PG Department shall send a panel of examiners for conducting the qualifying examination (Form 4). However, the University can draw its own panel of examiners.

ii. The panel of examiners for qualifying examinations shall be given three months before the date of completion of the student's course work.

16.3 **Written examination**:

i. Normally the qualifying examination shall be completed before the end of third semester of the postgraduate programme.

ii. The controller of examination shall conduct the qualifying written examination

iii. The written examination shall be conducted for major courses only.

iv. The question paper for the written examination shall be of 3 hours duration and each question need not be restricted to any particular topic in a course but it should be a comprehensive of the syllabus of each course.

v. The question paper pattern for the written examination is given below.

Part	Type of question	Number of questions	Number of questions to be answered	Mark per question	Total marks
A	Paragraph answers	7	5	5	25
B	Essay type answers	7	5	15	75
				TOTAL	**100**

16.4 **Oral examination:**

i. Only those students who secure 'SATISFACTORY' grade in written qualifying

examination shall be permitted to attend the oral qualifying examination

ii. The advisory committee shall conduct the oral examination with one external examiner, who sets the question paper for the written qualifying examination.

iii. The performance of the student(s) in the qualifying viva-voce examination shall be graded as "Satisfactory" or "Not satisfactory".

iv. If the performance of the student is "Not Satisfactory" in the oral examination, he/she has to appear for the oral examination again.

16.5 **Communication of results of qualifying examination**:

i. The Chairman of the advisory committee shall act as Chairman for the examination committee.

ii. The Chairman of the advisory committee shall be responsible for communicating the results of the examination to the Controller of Examinations in the prescribed format (Form 5).

16.6 **Failure/absence in qualifying examination**:

i. A student is permitted to write the qualifying examination only three times including the regular attempt.

ii. A student who fails or absents in the comprehensive qualifying written/viva-voce examination shall apply to the University with the recommendation of the Chairman of the advisory committee, Head of the Department and the Dean for re-examination.

iii. A student who applies for re-examination should attend written examination and viva-voce after paying the prescribed re-examination fee.

iv. Re-examination shall not take place earlier than three months after the previous qualifying examination.

v. If a student fails even in the second re-examination (third attempt), he/she cannot continue as a student in the University for Award of Master's degree in the University.

vi. The research credits registered in the final semester shall not be evaluated unless he/she successfully completes the qualifying examination.

17. CREDIT SEMINAR

17.1 Seminar is compulsory for all the postgraduate students and each postgraduate student should register and present one seminar with 0+1 credit.

17.2 Registration of seminar credits is not allowed in the first semester.

17.3 **Seminar topic:**

i. The seminar topic should be only from the major field and should not be related to the area of thesis title.

ii. The seminar topics are to be assigned to the students by the Chairman at the beginning of the semester in which he/she registers seminar credits and the progress made by the student should be monitored.

17.4 **Evaluation of seminar:**

i. The students should prepare a seminar paper after reviewing all the available literature and present the seminar after completion of 80 per cent attendance in the semester in the presence of the Advisory committee, staff and postgraduate students of the concerned department.

ii. The circular on the presentation of the seminars by the postgraduate students may be sent to other departments to enable those interested to attend the same.

iii. After carrying out the corrections/suggestions, the student should submit two copies of the seminar papers, one to the Chairman and the other to the department.

iv. The performance of the student in the credit seminar has to be evaluated for 100 marks by the Advisory Committee. Grade Point may be given based on the following norms:

Particulars	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**

17.5 The students who fail to present the seminar must be awarded 'F' grade and the student should again register the seminar credits and present the seminar in the subsequent semester. The minimum of 80 per cent attendance requirement for presenting the seminar after re-registration need not be insisted.

17.6 Presenting a seminar is a must for the award of the degree.

18. THESIS RESEARCH

18.1 **Selection of topic:**

i. With the guidance of the advisory committee the students should identify the tentative area of research and include it in the plan of work.

ii. The advisory committee should guide the students in selecting a specific topic in the identified research area and for preparing a detailed proposal. While selecting the topic for thesis research, the specialization and competency of teachers, thrust area identified by the department, external funded schemes operated in the department and also the aptitude of the student may be taken into consideration.

iii. The topic for thesis research for the students of Master's programme should be of such a nature as to indicate a student's potentialities for conducting research and to train him in research.

iv. 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.

v. A certificate to this effect duly endorsed by the Chairman of the Advisory Committee shall accompany the thesis.

18.2 **Research proposal:**

i. The research proposal has to be presented by the student in a meeting organized by the Head of the department to get the opinion/suggestions of the teachers of the department for improving it.

ii. Three copies of the research proposal in the prescribed format (Form 3) should be sent to the Dean through the Head of the department for approval before the end of the semester in which the student has registered research credits for the first time or before taking up the field / laboratory experiments whichever is earlier.

18.3 **Evaluation of thesis research:**

i. 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 (Proforma-1). After scrutiny and approval, a copy of the programme has to be given to the student for carrying out the work during the semester.

ii. Attendance register must be maintained in the department for all the PG students to monitor whether the student has 80 per cent of attendance in research.

iii. After completion of 80 per cent attendance for research and on or before the last day of the semester, the advisory committee should evaluate the progress of research work as per the approved programme and award '**SATISFACTORY** or **NOT SATISFACTORY**' depending upon quantity and quality of work done by the student during the semester. The procedures of evaluating research credits under different situations are explained hereunder.

a. **SITUATION I**: The student has completed the research credits as per the approved programme and awarded '**SATISFACTORY**' by the advisory committee. Under the said situation the student can be permitted to register fresh block of research credits in the subsequent semester. If the student is awarded '**NOT SATISFACTORY**' he/she has to reregister the same block of research credits in the subsequent semester.

b. **SITUATION II**: If the student has not secured the minimum attendance of 80 percent, then the grade 'E' should be awarded. The student has to reregister the same block of research credits for which 'E' grade was awarded in the following semester with prior permission from the University. Until the completion of re-registered credits, the student should not be allowed to register for fresh block of research credits.

c. **SITUATION III**: The student could not complete the research work as per the approved programme of work for reasons beyond his/her control such as,

- Failure of crop.
- Non-incidence of pests or disease or lack of such necessary experimental conditions.
- Non-availability of treatment materials like planting materials chemicals, *etc*.
- Any other impeding/unfavorable situation for carrying out research.

Under the said situations III, Grade 'E' should be awarded. The student has to

reregister the same block of research credits for which 'E' grade was awarded in the following semester with prior permission from the University. Until the completion of re-registered credits, the student should not be allowed to register for fresh block of research credits.

d. SITUATION IV: When the student failed to complete the work even in the 'Second time' registration, the student will be awarded '**NOT SATISFACTORY**' and he/she has to reregister the same block of research credits in the subsequent semester with the prior permission from the University.

e. SITUATION V: If a student can not complete qualifying examination till the end of final semester, the research credits registered in the final semester shall not be evaluated unless he/she successfully completes the qualifying examination. The research credits registered by the student during the final semester shall be evaluated within 15 days from the date of declaration of result of the qualifying examination.

f. SITUATION VI: If a student secures 'F' grade in one or more course(s) and can not complete the course(s) till the end of final semester, the research credits registered in the final semester shall not be evaluated unless he/she successfully completes the course(s) in which he/she secures 'F' grade. The research credits registered by the student in the final semester shall be evaluated within 15 days from the date of declaration of result of the failed course(s). If the student fails to complete the course even in 1+2 attempts, 'E' grade shall be awarded for the research credits registered in the final semester and the student has to re-register the same block of research credits along with the re-registration of failed courses, with the approval of the University

18.4 **Re-registration of research credits**: Students have to obtain prior permission of the University for re-registering the research credits. However, the University can permit the registration of research credit only three times. Permission to register for the fourth time shall be given only by the Academic Council.

19. SUBMISSION OF THESIS

i. The research credits registered in the last semester of postgraduate programmes should be evaluated only at the time of the submission of thesis by the advisory. committee. Students can submit the thesis at the end of the final semester. The list of enclosures to be submitted along with the thesis is furnished in *Annexure-2*.

ii. If a postgraduate student has completed the thesis before the closure of the final semester, the Chairman can convene the advisory committee meeting and take decision on the submission of the thesis provided the student satisfies 80 per cent attendance requirement.

iii. Copy of the thesis to be sent for evaluation should be submitted in paper pack.

iv. After incorporating the suggestions of the examiners and those received at the time of viva-voce, the thesis should be submitted to the College/university in hard bound copies (four copies) and soft copies (in pdf format) in CDs (two copies).

v. During submission of thesis for external evaluation, it is mandatory to enclose

certificates for plagiarism check and reference management (Proforma-12). Maximum of 20% plagiarism is permitted.

19.1 **Grace period:**

i. Students can avail a grace period upto three months for submission of thesis after the closure of final semester by paying prescribed fine to the University.

ii. If a student is not able to submit the thesis within three months grace period, the student has to re-register the credits in the forthcoming semester.

iii. The student who re-register the credits after availing the grace period will not be permitted to avail grace period for the second time.

iv. The Heads of the Departments can sanction the grace period based on the recommendation of advisory committee and a copy of the permission letter along with the receipt for payment of fine should accompany the thesis while submission.

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

19.3 **Publication of articles:** Part of thesis may also be published in advance with the permission of the Chairman. If any part is published, the fact should be indicated in the certificate given by the Chairman that the work had been published in part/ full in any referred scientific or popular journals, proceedings, *etc*.

20 EVALUATION OF THESIS

20.1 The thesis submitted in partial fulfillment of a Master's degree shall be evaluated by an external examiner nominated by the Controller of Examinations. However, the Dean can send panel of three examiners (Form 6).

20.2 An oral examination will be conducted by the Advisory Committee after the thesis is recommended by the external examiner and carrying out the corrections/suggestions made by the external examiner by the student.

20.3 The Chairman of the advisory committee shall communicate the date of final thesis viva-voce examination to the student and advisory committee members. The thesis final viva-voce examination shall be completed within three months from the date of receipt of the report from the external examiner.

20.4 The Chairman shall send the recommendations of the advisory committee (Form 7) along with necessary certificate/documents in duplicate to the University.

20.5 i. In case, the External examiner does not recommend the thesis for the award of the degree, the advisory committee may send their recommendation for scrutiny of the thesis by another external examiner, through the Dean to Controller of Examinations within one month from the date of receipt of the thesis. The Controller of Examinations may, on the recommendation of the advisory committee and Dean, refer the thesis for scrutiny and independent judgment to a second external expert chosen by him.

ii. If the second external expert recommends the thesis for acceptance, this recommendation may be accepted.

iii. If the second examiner also does not recommend the thesis for acceptance, the degree shall not be awarded.

21 REVISION OF THESIS

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

i. For revision of draft, the thesis should be resubmitted after a minimum of one month from the date of communication from the Dean.

ii. If the revision is recommended for repeating lab experiments, field trial *etc*, resubmission must be after a minimum period of six months.

21.2 At the time of resubmission, the advisory committee should give a certificate for having carried out the corrections/recommendations. The resubmitted copies of thesis should have incorporated the necessary corrections as indicated by the external examiners.

22 FAILURE TO APPEAR FOR FINAL VIVA/NON-SUBMISSION OF THESIS AFTER VIVA

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

22.1 The thesis viva-voce must be completed within **five years from the date of first registration** for Master's programmes. The prescribed penalty/fine must be charged to the candidate.

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

23 MALPRACTICES IN EXAMINATION AND MISCONDUCT OF STUDENTS

23.1 The Dean of the College shall be responsible for dealing all cases of unfair means by students in writing records, term papers and mid-semester examinations.

23.2 In case of final theory and final practical examination, the cases of malpractice will be dealt as per Chapter XV (A) of the Academic Ordinance of the University.

23.3 **Ragging rules:** Students found involved in ragging will be dealt as per the orders of the Supreme Court of India. The matter shall be reported to the University.

23.4 **Unlawful activities:** In case of students found involved in any unlawful activities either within or outside the Hostel/College Campus, besides, expulsion both from the Hostel and College at the discretion of the Dean, the matter will be reported to the Police of the jurisdiction to be dealt with, in accordance with the appropriate law in force. The matter shall be reported to the University.

24 The schedule for the important records to be sent to the Dean is furnished below and should be followed strictly so as to get back the above academic reports in time for maintenance in the students file.

Sl. No.	Particulars	Time Schedule
1	Formation of advisory committee **(Form 1)**	Within one month of the commencement of first semester
2	Plan of course work **(Form 2)**	Before the commencement of mid semester examination in the first semester
3	Programme of research work **(Form 3)**	Before the end of the semester in which the student registers the research credit for the first time or the commencement of the research work whichever is earlier.
4	Proposal for qualifying examination **(Form 4)**	Two months before the completion of the course work.
5	Qualifying examination result **(Form 5)**	Immediately
6	Panel of external examiners for thesis evaluation **(Form 6)**	Three months before the probable date of submission of thesis
7	Final viva-voce result **(Form 7)**	Fifteen days from the examination

25 AWARD OF DEGREE AND ISSUE OF TRANSCRIPT CARD

25.1 **Eligibility for the Award of the Degree:** The successful completion of all the prescribed courses included in the Curricula and Syllabi shall be minimum requirement for the award of the Degree.

25.2 **Class Ranking**: In calculation of Class equivalent for OGPA the following classification will be adopted. First class with Distinction and first class shall be awarded to those students who have completed the course without arrear and all others shall be awarded second class

OGPA	Class
9.00 and above	First class with Distinction
8.00 to 8.99	First class
7.00 to 7.99	Second Class

25.3 **Percentage conversion**: For obtaining the percentage equivalent to the OGPA, the OGPA secured by the student shall be multiplied by 10.

25.4 **Transcript card:**

i. The Transcript card shall contain entry of all the courses and the Grade Points and OGPA obtained by the candidates indicating the number of times appeared. This will have to be prepared for all the students by the Controller of Examinations.

ii. For preparation of Transcript card, the Dean should send recent passport size photograph of the students along with filled in proforma and the prescribed fee.

26 REMOVAL OF DIFFICULTIES:

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

26.2 Every order issued by the Vice-Chancellor under this provision shall be laid before the Academic Council of the University in the next meeting after the issuance.

26.3 Not-withstanding anything contained in the regulations, the Board of Studies or Academic Council reserve the right to make changes whenever necessary.

27. REGULATIONS GOVERNED BY PAJANCOA & RI

27.1 ADMISSION

27.1.1 Application for admission:

i. Application for admission shall be made in the prescribed form to be downloaded from the website of the college (www.pajancoa.ac.in) after notification is issued to this effect.

ii. The admissions shall be regulated and made in accordance with the admission rules and regulations in force.

iii. Candidates seeking admission to the various Postgraduate degree courses are permitted to apply for only two subjects. Separate applications should be used for each course.

27.1.2 Admission procedure:

i. The admission is based on the merit category of the candidate and availability of vacancies at the time of counseling.

ii. All admissions made by this Institute are provisional and subject to the approval of the University.

iii. The candidates who have offered admission should report to the college on or before the due date mentioned failing which their right of admission is forfeited

27.2 FEE STRUCTURE

27.2.1 Fee structure is being revised every year with 10% fee hike. Lodging fees and charges for electricity, water and computer are revised based on the requirements and power tariff prevailing from time to time.

27.2.2 In the case of new admissions, the fees for the first semester should be paid at the time of admission.

27.2.3 For the remaining semesters, the fees should be paid on the date of registration of the semester.

27.2.4 Candidates who discontinue after admission are not eligible for refund of fees except caution money deposit.

27.2.5 In case of a student who re-registers with junior batch, he/she has to pay the semester fess applicable to the junior batch in which he/she registers, besides the re-registration fee.

27.3 REGISTRATION

27.3.1 All newly admitted candidates should register during the first semester of the programme. A candidate admitted to the Postgraduate programme should report to the Head of the Department concerned on the date of registration. It is the

responsibility of the candidate to register the courses in person on the due date prescribed for the purpose.

27.3.2 **In ABSENTIA** registration will not be permitted on any circumstances.

27.3.3 The Head of the Department and the PG coordinator shall help the student in selecting the courses for registration.

27.3.4 Admitted candidates shall register with the respective Department at the beginning of each semester and this should be completed within two working days.

27.3.5 **Late registration**:

i. Late registration is permitted by the Dean of college within seven working days from the commencement of the semester provided the prescribed late registration fee is paid before registration.

ii. Registration beyond seven working days is not allowed except for new entrants who are admitted late due to administrative reasons in the first semester.

27.3.6 **Registration cards:**

i. A student shall register the courses offered in a semester by writing all the courses in registration card in quadruplicate. The format of registration card is given in *Annexure-4*.

ii. The Chairman, PG coordinator and Head of the Department are responsible to furnish the registration particulars of the students with their signature in the Registration card to the Dean.

iii. The Dean shall approve the registration cards.

iv. The approved registration cards shall be maintained by the Dean, PG coordinator, Chairman and the student concerned.

v. The list of courses registered by the students in each semester shall be sent by the Dean to the Controller of Examinations/University for preparation of Report Cards

27.3.7 The mess dues clearance certificate has to be produced by the student at the time of registration.

27.4 ARREAR EXAMINATION:

i. The prescribed arrear examination fee should be paid on or before the specified date.

ii. The Registration for the arrear examination shall be done on the date specified by the Dean. Each registration is considered as an attempt even if the student is absent for the examination.

27.5 QUALIFYING EXAMINATION

The Heads of departments will monitor and coordinate the conduct of both the written and oral qualifying examinations.

27.6 SUBMISSION OF THESIS

The research credits registered in the last semester of postgraduate programmes

should be evaluated only at the time of the submission of thesis by the advisory committee. Students can submit the thesis at the end of the final semester. The list of enclosures to be submitted along with the thesis is furnished in *Annexure-5*.

27.7 REVISION OF THESIS

The prescribed fine for late submission of revised thesis may be collected from the students submitting thesis beyond the due date with the recommendation of the Chairman. The Dean shall ensure that the delay is due to the fault of the student.

27.8. MERIT SCHOLARSHIP/RESEARCH ASSISTANTSHIP

27.8.1 PAJANCOA & RI PG fellowship shall be awarded to all the students who are admitted into the Masters programme based on allotment of Government fund. The PG students should be a resident of PAJANCOA & RI hostels. The award of PG fellowship is governed by the approved PG fellowship rules.

27.8.2 The Dean shall call for applications and sanction the scholarship every year.

27.8.3 The students availing any scholarship/fellowship are permitted to switch over to other fellowship/scholarship only one time during the course of study.

27.8.4 **Student SRF/JRF:**

i. The selection of student SRF/JRF in external funded schemes will be made by the existing committee members for selection of regular SRF/JRF.

ii. The PG coordinator of the concerned department will be an additional member of the committee.

iii. The panel of names after the selection has to be sent to the Dean for approval in the prescribed Proforma.

iv. If a student SRF/JRF discontinues before submitting the thesis or switch over to other fellowship/scholarship, the amount already paid has to be recovered in full in one lump sum with 6% penal interest.

27.9 RECOGNITION OF POSTGRADUATE TEACHERS

27.9.1 The Dean normally recognizes teachers for offering courses and guiding the students of Master's programme based on the request of teachers and the recommendation of Head of the department.

27.9.2 The recognized PG teachers shall offer courses to masters students as required by the concerned Heads of departments, normally, in their own field of specialization unless extra-ordinary circumstances demand for offering other courses.

27.9.3 All the recognized guides for Master's programme are competent to guide research work of Master's degree students in their own fields of specialization. The Heads of departments shall assign students to the recognized guides taking into account their specialization. The students should be uniformly distributed instead of all of them taking research topics in one or two specialized branches in the department.

27.9.4 **Teachers for Master's programme:** The following faculty shall be recognized as PG teachers for Master's programme

i. Professors
ii. Associate Professors
iii. Assistant Professors: Persons having Ph.D. degree with one year of active experience in the concerned field (or) Persons having a Master's degree with three years of active experience in the field. In case of contingencies, like start of new PG programme, persons having Ph.D. degree in the concerned field may be recognized as PG Teacher.

27.9.5 **Guides for Masters programme:** PG Teachers after handling PG courses in two semesters are eligible to guide M. Sc. students. In case of contingencies, like start of new PG programme, persons having Ph.D. degree in the concerned field may be recognized as PG Guide.

27.9.6 The Heads of departments will forward the proposals based on the qualification and experience of the teacher as given above. The proposals can be sent when there is acute need for teachers/guide in the prescribed format, given in the *Annexure-6*.

27.9.7 While forwarding the application the Head of the Department should consider the seniority of the teacher, number of courses handled and number of research schemes operated.

27.10 GUIDELINES FOR HEADS OF THE DEPARTMENTS IN MONITORING PROGRESS OF POSTGRADUATE STUDENTS

27.10.1 **Student records:** The "Individual student" file (clip file) containing all the academic records of the student concerned with students bio-data shall be maintained by the PG coordinator on behalf of the Institution. In each file a sheet containing the following information has to be attached.

i) Date of registration :
ii) Date of qualifying examination :
iii) Due date for thesis submission :
iv) Date of submission of thesis :
v) Date of viva-voce :
vi) Remarks :

27.10.2 The activities listed out in the following table must be meticulously taken care by the Professor and Head of the Department concerned

Sl.No.	Particulars	Time Schedule
1	List of courses to be offered along with time table	A week before the commencement of each semester
2	Course registration particulars	Within 10 working days from the date of commencement of each semester
3	Time table for mid-semester examinations	A week before the scheduled date for the examinations notified in the academic calendar
~~4~~	Mark lists after completing examinations	Within 10 days from the date of conduct of examinations
5.	Class grade chart	Within 7 days from the date of closure of each semester

27.10.3 The time table for various examinations and evaluations of research credits should be prepared in advance as indicated in the academic calendar of semester concerned and such dates already fixed should not be postponed or changed subsequently.

27.10.4 The Heads of the Departments should monitor the progress of the postgraduate students. Each department should maintain a list of thesis produced so far with the abstract of the same in both hard and soft copies.

Form – 1

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

FORMATION OF ADVISORY COMMITTEE

(To be sent in triplicate within one month from the commencement of First semester)

1. Name of the student :
2. Registration No. :
3. Degree :
4. Subject :
5. Advisory committee :

Sl. No.	Advisory Committee	Name, Designation and Department	Date of Retirement	Signature
1	Chairman			
2	Member 1			
	Member 2			
3	Additional Member			

6. Reason for additional member :

Signature of the student

PG coordinator **Head of the Department**

DEAN

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

Form – 1a

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

CHANGE IN ADVISORY COMMITTEE

(To be sent in triplicate)

1. Name of the student :
2. Registration No. :
3. Degree :
4. Subject :
5. Proposed change :

		Name and designation	Date of retirement	Signature
a.	Existing Chairman/ member			
b.	Proposed Chairman/ member			

6. Reasons for change :

Signature of the student

Chairman of the Advisory Committee **PG coordinator**

Head of the Department **DEAN**

Form – 2

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

PLAN OF COURSE WORK

(To be sent in triplicate before the commencement of mid semester examinations in the first semester)

1. Name of the student :
2. Registration No. :
3. Degree :
4. Subject :
5. Course Programme :

S. No	Course No	Course Title	Credit Hour
		MAJOR COURSES	
		MINOR COURSES	
		SUPPORTING COURSES	
		NON-CREDIT COURSES	
		SEMINAR	
		RESEARCH	
		TOTAL	

6. Tentative area of research :
   (indicate the major field of specialization)

Signature of the student

APPROVAL OF THE ADVISORY COMMITTEE

Advisory committee	Name	Signature
Chairman		
Members	1.	
	2.	
	3.	

PG coordinator **Head of the Department**

DEAN

Form – 3

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

PROGRAMME OF RESEARCH WORK

(To be sent in triplicate before the end of the semester in which the student registers research credit for the first time or the commencement of research work whichever is earlier)

1. Name :
2. Registration No. :
3. Degree :
4. Subject :
5. Date of joining :
6. Title of the research project :
7. Objective(s) :
8. Duration :
9. Location (campus/station) :
10. Review of work done :
11. Broad outline of work/methodology :
12. Semester wise break up of work :

Signature of the student

APPROVAL OF THE ADVISORY COMMITTEE

Advisory committee	Name	Signature
Chairman		
Members	1.	
	2.	
	3.	

PG coordinator **Head of the Department**

DEAN

Form – 3a

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

CHANGE IN PROGRAMME OF RESEARCH

(To be sent in triplicate)

1. Name :
2. Registration No. :
3. Degree :
4. Subject :
5. Reason for change :
6. Proposed change in the approved : programme of research
7. Number of credits completed so far : under the approved programme
8. a) Whether already earned credits are : to be retained or to be deleted

   b) If retained, justification :

Signature of the student

APPROVAL OF THE ADVISORY COMMITTEE

Advisory committee	Name	Signature
Chairman		
Members	1.	
	2.	
	3.	

PG coordinator **Head of the Department**

DEAN

Form – 4

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

PROPOSAL OF QUALIFYING EXAMINATION

(To be sent in triplicate)

1. Name of the Department :
2. Degree :
3. Subject :
4. Whether all the courses have been completed :
5. Number of credits completed :
6. Whether the students have an OGPA of not less than 7.00/10.00 :
7. List of PG students appearing for qualifying examination :

Sl. No.	Name	Registration No.	OGPA

8. Panel of External examiners :

Sl. No.	Name and Designation	Address	Area of specialization
1.			
2.			
3.			

9. Remarks :

PG coordinator **Head of the Department**

DEAN

Form – 5

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

COMMUNICATION OF RESULT OF QUALIFYING EXAMINATION

(To be sent in triplicate)

1. Name of the student :
2. Registration No. :
3. Degree :
4. Subject :
5. Date of examination :
6. Date of previous examination (only in case of re-examination) :
7. Result (Successful/ Not successful*) :

(*) to be written by the external examiner

EXAMINATION COMMITTEE

	Name in block letters	**Signature**
Chairman		
Members	1.	
	2.	
	3.	
External Examiner		

Signature of Chairman with name and designation

PG coordinator

Head of the Department

DEAN

Form – 6

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

PROPOSAL OF EXTERNAL EXAMINERS FOR THESIS EVALUATION

(To be sent in duplicate in Confidential cover)

1. Name of the student :
2. Registration No. :
3. Degree :
4. Subject :
5. Thesis title :
6. Name of the Chairman :
7. Panel of external examiners* :

Sl. No.	Name and Designation	Address	Area of specialization
1.			
2.			
3.			

*Three external examiners should be given

8. Remarks :

Signature of the Chairman of the advisory committee

DEAN

.

Form – 7

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

RESULT OF FINAL THESIS VIVA-VOCE EXAMINATION

(To be sent in duplicate)

1. Name of the student :
2. Registration No. :
3. Degree :
4. Subject :
5. Thesis title as in final copy of the thesis :
6. Date and time of *viva-voce* :
7. Particulars of the External examiner(s) who has/have evaluated the thesis :

Name and Designation of the External Examiner	**Remarks of the External Examiner**
	RECOMMENDED / RECOMMENDED FOR REVISION / NOT RECOMMENDED

8. **Recommendation of the Examining committee present at the time of final *viva voce* examination**:
   a. Recommends/ does not recommend unanimously the award of degree
   b. The performance of the candidate in final *viva voce* is assessed as _____ (very good/ good/ satisfactory/ not satisfactory)

Sl. No.	**Capacity of examiner**	**Name in block letters**	**Signature**
1.	Chairman/Co-opted Chairman*		
2.	Member 1.		
3.	2.		
4.	Additional member		
5.	Co-opted member*		

* If co-opted in the absence of Chairman/Member

The original report(s) from the external examiner(s) is/ are enclosed

Head of the Department

Chairman of the Examining committee / Advisory committee with designation

Annexure – 1

DETAILS ON FEE TO BE PAID BY THE STUDENT

(Other than admission fee and semester fee)

Sl. No.	Particulars	Amount (Rs.)
1.	Late Registration fee	1000
2.	Missing mid-semester examination fee (per course)	1000
3.	Re-registration fee with juniors	1000
4.	Duplicate Hall ticket	200
5.	Fee for Transfer Certificate and Conduct Certificate	200
6.	Re-examination fee for qualifying exam	5000
7.	Fee for availing grace period for submission of thesis	
	a) Upto one month	1000
	b) Up to three months	2500
8.	Penalty for re-viva voce examination for thesis	5000
9.	Fee for late submission of thesis after final viva-voce	5000
10.	Examination fee (per course)	*
11.	Arrear Examination fee (per course)	*
12.	Revaluation fee (per course)	*
13.	Re-totaling fee (per course)	*
14.	Fee for Provisional Degree Certificate	*
15.	Fee for Transcript Card	*
16.	Fee for Degree Certificate	*
17.	Fee for Migration Certificate	*

*** As fixed by Pondicherry University from time to time**

Annexure – 2

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAIKAL – 609 603

STUDENT REGISTRATION CARD - PG

Name of the student _____ Academic Year _____

Registration No. _____ Semester _____

Degree Programme _____ Date of Registration _____

Year of Admission _____ Date of Commencement _____

COURSES REGISTERED

Sl. No.	Course Code	Course Title	Credit Hours	Remarks
		TOTAL CREDIT HOURS REGISTERED		

Signature of the Student	**Signature of the Chairman**	**Signature of the Head of the Department**	**Coordinator of Examinations**

APPROVED BY

DEAN
PAJANCOA&RI, KARAIKAL

Annexure-3

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

LIST OF ENCLOSURES TO BE SUBMITTED ALONG WITH THESIS

A. At the time of sending thesis for External Evaluation:

To be submitted to the university

1. One copy of abstract of thesis
2. One copy of the summary of research finding in English (within one page)
3. One copy of the summary of research finding in Tamil (within one page)
4. One page abstract of thesis with key words
5. Result of comprehensive qualifying examination
6. Permission and fee receipt for availing grace period, if any.

To be submitted to the college along with above list

7. Clearance certificates from Hostel
8. Clearance certificates from Library
9. Clearance certificates from Department
10. Clearance certificates from Staff advisor
11. Clearance certificates from Physical Education
12. Approved registration cards (One set)
13. Report cards (one set)
14. Course completion certificate (signed by Chairman and HOD)
15. Attendance Certificate

B. At the time of submission after final viva-voce:

1. Report of the final thesis viva voce examination (To be sent in duplicate)
2. External Examiners thesis evaluation report (Two copies – original + Xerox)
3. Certificate for having carried out the suggestions of the external examiner and advisory committee
4. Thesis in hard bound copy – One Number.
5. Soft copy the thesis in CD (cover to cover in PDF format) - Two Number.

Annexure - 4

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

PROPOSAL FOR RECOGNITION OF TEACHERS FOR TEACHING/GUIDING PG STUDENTS

1. Particulars of the teacher seeking recognition

a. Name of the teacher :

b. Date of birth of the teacher :

c. Designation & present official address of the teacher :

d. Date of joining service in the entry cadre :

e. Academic qualifications

Date of acquiring Bachelor's Degree :

Date of acquiring Master's Degree :

Date of acquiring Ph.D degree :

f. Total service as on the date of this proposal (excluding extraordinary leave) :

g. Date of retirement :

2. Recognition proposal submitted for (tick any one)

a. Recognition as teacher for Masters Programme

b. Recognition as Guide for Masters Programme

3. Teaching experience as on the date of Application

a. No. of UG courses offered :

c. No. of M.Sc courses offered :

Signature of the teacher with date

4. Particulars to be furnished by Head of the Department

No. of existing recognized teachers/guides pertaining to this proposal in your department :

Justification for additional requirement of teachers/guide :

Signature of the Head of Department

Approval of the Dean

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

PROFORMA FOR REGISTRATION OF RESEARCH CREDITS

PART- A : PROGRAMME

Semester : I / II Year : Date of registration :

1. Name of the student :
2. Registration No.
3. Total research credits completed so for :
4. Research credits registered during the semester :
5. Programme of work for this semester :
   (list out the items of research work to be undertaken during the semester)
   i)
   ii)
   iii)
   iv)

APPROVAL OF THE ADVISORY COMMITTEE

Advisory committee	Name	Signature
Chairman		
Members	1.	
	2.	
	3.	

(Approval may be accorded within 10 days of registration)

PROFORMA FOR EVALUATION OF RESEARCH CREDITS

PART - B EVALUATION

(Evaluation to be done before the closure of semester)

Date of closure of semester :

Date of evaluation :

1. Whether the research work has been carried out as per the approved programme :
2. If there is deviation specify the reasons :
3. Performance * :

(*) Performance may be indicated as **SATISFACTORY /NOT SATISFACTORY**

APPROVAL OF THE ADVISORY COMMITTEE

Advisory committee	**Name**	**Signature**
Chairman		
Members	1.	
	2.	
	3.	

Proforma-2

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

PERMISSION FOR LATE REGISTRATION

1.	Name of the student	:
2.	Registration No.	:
3.	Degree	:
4.	Department	:
5.	Semester and Academic year	:
6.	Date of commencement	:
7.	Date of registration without fine	:
8.	Last date for registration with fine	:
9.	Date on which registration is sought	:
10.	Reason	:
11.	Signature of the student	:
12.	Remarks and recommendation of the Chairman	:

Signature of the Chairman

PG Coordinator **Head of the department**

DEAN

Proforma-3

PONDICHERRY UNIVERSITY
PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

WILLINGNESS TO BE GIVEN BY THE STUDENTS TO AVAIL FELLOWSHIP FROM EXTERNALLY FUNDED SCHEMES

1.	Name of the student	:
2.	Registration No.	:
3.	Degree	:
4.	Subject	:
5.	OGPA of Bachelor degree	:
6.	Name of the Chairman	:
7.	Discipline/Department	:
8.	Thesis topic, if allotted	:
9.	Current semester and year in which studying	:
10.	Whether all the course works have been completed , if not indicate the pending courses with credit loads	:

Undertaking by the student:

i. I am willing to avail the proposed fellowship under the scheme entitled_____ _____.

ii. If I leave in the middle of the tenure of the fellowship, I am willing to repay the fellowship availed with 6% penal interest or any levy/fine imposed by the College/University.

iii. I am fully aware that in case of campus transfer due the award of the fellowship that I have to loose the research credits already registered.

iv. I am fully aware that there is no guarantee for the continuation of the courses, which I currently undergo, in the other campus to which I am likely to be transferred.

v. I am willing to abide by all the rules and regulations laid down by the College/University in this regard.

Date: **Signature of Student**

Chairman of the Advisory Committee **Head of the Department**

DEAN

Proforma-4

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

ALLOTMENT OF STUDENTS UNDER JRF/SRF STUDENT FELLOWSHIP

(To be submitted to the Dean)

1.	Title of the scheme	:	
2.	Location of the scheme (Department)	:	
3.	Date of sanction of the scheme	:	
4.	Period of the scheme	:	
5.	Type of fellowship	:	JRF/SRF
6.	Period of fellowship (only for the period of research credits registered)	:	
7.	Amount of fellowship	:	Rs……..p.m
8.	Amount of contingent grant	:	Rs……p.a.
9.	Amount of T.A. provided	:	Rs……..p.a.
10.a.	Whether the technical programme submitted by the student to Dean is the same as envisaged in the scheme proposal	:	Yes / No
b.	If not, whether the revised programme of research is submitted (If yes, date of approval by the Dean)	:	
11.	No. of research credit(s) completed so far by the proposed fellowship awardees (student)	:	
12.	Whether the credits earned earlier are to be retained or to be cancelled?	:	
13.	Whether funds received	:	Yes / No
14.	Name of the student(s) & ID.No.	:	
15.	Number of semesters for which fellowship may be sanctioned	:	
16.	Can the fellowship be sanctioned for grace period also.	:	Yes / No

Principal Investigator **Head of the Department** **Dean**

List of Enclosures

1. Copy of concurrence of the sponsor of the sponsor to avail student fellowship
2. Copy of administrative sanction by Dean
3. Student's willingness and undertaking

Proforma-5

PONDICHERRY UNIVERSITY
PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

SPONSOR'S CONCURRENCE (PROFORMA)

1.	Title of the scheme	:	
2.	Location of the scheme (Department)	:	
3. a.	Name & Designation of the PI	:	
b.	Name and designation of the Co-PI	:	
4.	Type of fellowship	:	JRF/SRF
5.	Period of fellowship	:	
a.	Indicate the period of fellowship to be awarded	:	
b.	Amount of fellowship	:	Rs……p.m.
c.	Amount of contingent grant	:	Rs……p.a.
d.	Amount of T.A. Provided	:	Rs……p.a.
e.	Whether Institutional charges paid	:	Yes/No Rs……

Signature of the Sponsor

To
The Dean
PAJANCOA&RI
Karaikal – 609 603

Proforma-6

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

DEPARTMENT OF _____

COURSE COMPLETION CERTIFICATE

This is to certify that Thiru./Selvi/Tmt. _____ Registration No. _____ has completed all the course and research credit requirements on _____ for the award of _____ degree.

Professor and Head

Signature of the Chairman
(with Name and designation)

Proforma-7

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

JUSTIFICATION FOR LATE SUBMISSION OF THESIS (if applicable)

1. Name of the student :
2. I.D. No. :
3. Degree :
4. Subject :
5. Date of first registration for the degree :
6. Number of semesters for which the candidate could not register :
7. Reason for not registering and continuing the study :
8. Period of delay in submission of thesis :
9. Period lost due to transfer/ill health :
10. Date of submission of thesis :

Signature of the student

11. Specific remarks and recommendation of the Chairman :

Signature of the Chairman with designation

12. Specific remarks and recommendation of the Head of department :

Signature of the Head

13. Approval of the Dean :

Signature of the Dean

Proforma-8

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

PROFORMA FOR EVALUATION OF THESIS

Name of the degree programme: _____.

1. Name and Designation of the examiner :

2. Address of the Examiner :

   Telephone/Mobile :
   Fax :
   e-mail :

3. Name of the candidate :

4. Registration No. :

5. Title of the thesis :

6. Date of receipt of the thesis copy :

7. Date of despatch of the detailed report and thesis by the examiner to the Dean :

8. Examiner's recommendations choosing one of the following based on quality of thesis :
   a. Recommended for award
   b. Recommended for revision

9. Please state whether a list of questions if any to be asked at the viva-voce examination (Questions to be attached) :

Date :
Official Seal :

Signature of the Examiner

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

Proforma-9

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

DEPARTMENT OF _____

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

(To be enclosed along with result of the final viva voce examination)

Certified that Thiru/Selvi/Tmt _____

Registration No. _____ has carried out all the corrections and suggestions as pointed out by the external examiners(s) and the advisory committee and has submitted **FOUR** copies of his/her M.Sc. thesis in hard bound cover and **TWO** soft copies of thesis in PDF format in CDs.

Head of the department

Signature of the Chairman with Name and designation

Proforma-10

PONDICHERRY UNIVERSITY
PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

PROFORMA FOR OBTAINING PERMISSION TO PRESENT PAPERS IN SEMINAR/SYMPOSIA/TRAINING

(To be sent in triplicate)

1.		Name of the student	:
2.		Registration No.	
3.		Department & College	:
4.		Name of the Chairman with designation	:
5.		Whether course work has been completed?	
6.		Title of paper/poster to be presented (enclose copy)	:
7.	a.	Name of the seminar/symposium	:
	b.	Venue	:
	c.	Dates(From-To)	:
8.		Period of absence (in days) inclusive of travel time	:
9.		Whether the paper was sent through proper channel (copy to be enclosed)	:
10.		Cost of travel & registration fee borne by the student himself (or) supported by the scheme in which he is drawing fellowship?	:

Date: Signature of the Student

Specific Recommendations:

Chairman **Professor and Head**

PERMISSION TO ATTEND THE SEMINAR/SYMPOSIA

(to be issued by the Dean)

1. Permitted without any financial commitment to the College/ University / **Not permitted**
2. Period of absence from_____ to _____(_____ days) is to be treated as duty and can be counted for attendance.
3. Period of absence from _____to _____(_____days) **is not treated as duty and cannot be counted for attendance.**
4. The student should submit a report to the Dean, within 3 days after his return.

DEAN

Proforma-11

PONDICHERRY UNIVERSITY
PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

APPLICATION FOR ISSUE OF CONDUCT AND TRANSFER CERTIFICATES

(To be submitted by the student with the recommendation of the Chairman/Head)

1. Name of the student :
2. Registration No. :
3. Name of the Chairman :
4. Designation of the Chairman :
5. Name of the course undergone :
6. Year of joining course :
7. Year of leaving the course :
8. Whether copy of the PC enclosed :
9. Whether original clearance certificate from warden enclosed :

Date: **Signature of the Student**

Recommendations:

Certified that the conduct and characters of Mr/Ms. _____ were _____ during the period of his/her studies. The certificates may be issued accordingly.

Chairman **PG Co-ordinator** **Professor & Head**

Proforma-12

PONDICHERRY UNIVERSITY
PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARIAKAL – 609 603

CERTIFICATE FOR HAVING CARRIED OUT PLAGIARISM CHECK

1	Name of the Student	
2	Registration Number	
3	Degree	
4	Title of the Thesis	
5	Name of the Chairman	
6	Total Word Count in the Document	
7	Initial Submission	Yes / No
	If No	Provide the number of times plagiarism checked along with their plagiarism percent
8	Date of Submission	

Signature of the Student

Signature of the Chairman/Chairperson

Signature of the Head of the Department

COURSE CURRICULA AND SYLLABI

DESCRIPTION OF TERMINOLOGIES

Major Course The subject of Department or discipline in which the student takes admission. Among the listed courses, the core courses compulsorily to be registered shall be given '*' mark

Minor Course The course closely related to a student's major subject

Supporting Course The course not related to the major course. It could be any course considered relevant for student's research work or necessary for building his/her overall competence

Common course Course which is compulsorily registered by the postgraduate student for the completion of postgraduate degree programme. The marks obtained by the student in a common course will also be taken into account for calculating OGPA

Credit Requirements

	Particulars	Credits
(i)	**Course Work**	
	Major courses	20
	Minor courses	08
	Supporting courses	06
	Common courses	05
	Seminar	01
(ii)	**Thesis Research**	30
	TOTAL	**70**

COMMON COURSES

Sl No.	Course Code	Course Title	Credits
1	PGS 501	Library and Information Services	0+1
2	PGS 502	Technical Writing and Communication Skill	0+1
3	PGS 503	Intellectual Property and its Management in Agriculture	1+0
4	PGS 504	Basic Concepts in Laboratory Techniques	0+1
5	PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1

AIM OF THE COURSE

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

PRACTICAL

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

PRACTICAL SCHEDULE

1. Introduction to library and its services
2. Role of libraries in education, research and technology transfer;
3. Classification systems and organization of library
4. Sources of information- Primary Sources, Secondary Sources and Tertiary Sources
5. Intricacies of abstracting and indexing services
6. Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.);

7. Tracing - information from reference sources;
8. Literature survey
9. **Mid- Semester**
10. Citation techniques/Preparation of bibliography;
11. Use of CD-ROM Databases,
12. Online Public Access Catalogue and other computerized - library services
13. Online Public Access Catalogue and other computerized - library services
14. Use of Internet including search engines and its resources
15. Use of Internetincluding search engines and its resources
16. E-resources access methods.
17. Final practical examination

PGS 502 TECHNICAL WRITING AND COMMUNICATION SKILLS 0+1

AIM OF THE COURSE

To equip the students with skills *Viz.,* writing of dissertations, research papers, etc. andto communicate and articulate in English (verbal as well as writing)

PRACTICAL

Grammar - Tenses, parts of speech, clauses, punctuation marks; Error analysis Common errors; Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers. Proof reading. Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Structure of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

PRACTICAL SCHEDULE

1. Grammar (Tenses, parts of speech)
2. Grammar (clauses, punctuation marks)
3. Error analysis (Common errors); Concord; Collocation;
4. Phonetic symbols and transcription;
5. Accentual pattern: Weak forms in connected speech
6. Participation in group discussion
7. Facing an interview; presentation of scientific papers.
8. Technical Writing- Various forms of scientific writings- theses, technical papers

9. **Mid -semester examination**
10. Technical Writing- reviews, manuals
11. Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion)
12. Writing of abstracts, summaries, précis, citations etc
13. Commonly used abbreviations in the theses and research communications
14. Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustration
15. Writing numbers and dates in scientific write-ups
16. Editing and proof-reading, writing of a review article.
17. **Final practical examination**

SUGGESTED READING

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

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

AIM OF THE COURSE

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

THEORY

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

SUGGESTED READING

1. Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
3. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
4. Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
5. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
6. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1
(For Social Science)

PRACTICAL

Use of R / SPSS / equivalent for Frequency distribution, Summarization and tabulation of data, F test, Correlation, Pearson Correlation, Spearman Correlation, ANOVA, ANCOVA

Use of R / SPSS / equivalent for Regression: Simple, Multiple Linear regression, Estimation of regression by OLS & MLE method, Logit, Probit, Stepwise regression, Coefficient of determination

Use of R / SPSS / equivalent for Kolmogorov-Smirnov test, Wilcoxon signed rank test, Mann-Whitney U, Kruskal-Wallis, McNemar's test

Use of R / SPSS / equivalent for Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component.

Use of R / SPSS / equivalent for Analysis of time series data - AR, MA, ARIMA models

SUGGESTED READING

1. Anderson CW & Loynes RM. 1987. The Teaching of Practical Statistics. John Wiley.
2. Atkinson AC. 1985. Plots Transformations and Regression. Oxford University Press.
3. Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.
4. Chatfield C & Collins AJ. 1980. Introduction to Multivariate Analysis. Chapman & Hall.
5. Chatfield C. 1983. Statistics for Technology. 3 rd Ed. Chapman & Hall.
6. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.
7. Cleveland WS. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
8. Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
9. Erickson BH & Nosanchuk TA. 1992. Understanding Data. 2 nd Ed. Open University Press, Milton Keynes.
10. Snell EJ & Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman & Hall
11. Sprent P. 1993. Applied Non-parametric Statistical Methods. 2 nd Ed. Chapman & Hall.
12. Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
13. Velleman PF & Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
14. Weisberg S. 1985. Applied Linear Regression. John Wiley.
15. Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.
16. Wetherill GB.1986. Regression Analysis with Applications. Chapman & Hall.
17. Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
18. Free Statistical Soft wares: http://freestatistics.altervista.org/en/stat.php.
19. Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1
(For Plant Sciences)

AIM OF THE COURSE

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

PRACTICAL

Unit I

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separator funnel, condensers, micropipettes and vaccupets. Ashing, drying and sterilization of glassware; Drying of solvents/chemicals.

Unit II

Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions. Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values.

Unit III

Preparation of different agro-chemical doses in field and pot applications. Principles and handling techniques of Chromatography.

Unit IV

Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath. Preparation of media and methods of sterilization.

Unit V

Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy. Specific methodologies concerning each discipline

PRACTICAL SCHEDULE

1. Safety measures while in Lab; Handling of chemical substances
2. Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micro pipettes and vaccupets
3. Washing, drying and sterilization of glassware
4. Drying of solvents/chemicals
5. Weighingandpreparationofsolutionsofdifferentstrengthsandtheirdilution
6. Handling techniques of solution; Preparation and neutralisation of acid and bases
7. Preparation of buffers of different strengths and pH values
8. **Mid semester examination**
9. Preparationofdifferentagro-chemicaldosesinfieldandpotapplications (Herbicides and Fertilizers)

10. Preparationofdifferentagro-chemicaldosesinfieldandpotapplications (Pesticides)
11. Principles and Handling techniques of Chromatography.
12. Use and handling of microscope, laminar flow, vacuum pumps viscometer, thermometer, magnetic stirrer, micro-ovens, incubator, sand bath, water bath, oil bath etc.
13. Preparation of media and methods of sterilization
14. Seed viability testing, testing of pollen viability
15. Tissue culture of crop plants. Description of flowering plants in botanical term sin relation to taxonomy
16. Specific methodologies of each discipline concerned.
17. **Final Practical Examination**

SUGGESTED READING

1. FurrAK.2000.*CRC Hand Book of Laboratory Safety*. CRC Press.
2. Gabb MH and Latchem WE.1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

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

AIM OF THE COURSE

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

THEORY

Unit I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions.

Unit II

Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centers (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

Unit III

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

Unit IV

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme.

Unit V

Integrated Rural Development Programme (IRDP) Panchayat Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organizations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

LECTURE SCHEDULE

1. History of agriculture in brief; Global agricultural research system: need, scope, opportunities
2. Role in promoting food security, reducing poverty and protecting the environment
3. National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions
4. Consultative Group on International Agricultural Research (CGIAR); International Agricultural Research Centres (IARC)
5. Partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels
6. International fellowships for scientific mobility.
7. Research ethics: research integrity, research safety in laboratories
8. Welfare of animals used in research, computer ethics, standards and problems in research ethics.
9. **Mid semester examination**
10. Social trends on research ethics, adequate codes of conduct to regulate researchactivity
11. Concept and connotations of rural development, rural development policies and strategies.
12. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme
13. Special group – Area Specific Programme
14. Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations.
15. Critical evaluation of rural development policies and programmes
16. Constraints in implementation of rural policies and programmes
17. Final Examination.

SUGGESTED READING

1. Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publication. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

2. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publication.
3. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publication.

SUPPORTING COURSES

Sl No.	Course Code	Course Title	Credits
1	COM 501	R and Python Programming	2+1
2	MAT 501	Mathematics For Agricultural Economics	2+1
3	STA 501	Statistical Methods for Applied Sciences	2+1
4	STA 502	Design of Experiments	2+1

COM 501 R AND PYTHON PROGRAMMING 2+1

WHY THIS COURSE?

This course is all about R which is mainly used for statistical analysis while Python provides a more general approach to data science. R and Python are state of the art in terms of programming language oriented towards data science. Learning both of them gives an idea for handling agricultural data.

AIM OF THE COURSE

The objective of the course is partly to give an introduction to python and software R and how to handle data analysis using R.

THEORY

Unit I

Introduction to Python – Identifiers, Keywords, Statements and Expressions, Variables, Operators, Precedence and Associativity, Data Types, Reading Input, Print Output, Type Conversions - Control Flow Statements, Looping Statements, Functions - Built-In Functions, Commonly Used Modules, Packages - Strings and Lists – Iterators.

Unit II

Regular Expression - pattern matching and searching using regex - validations using regular expressions - Exception handling - Python Database Interaction - SQL Database connection using python - Creating, Reading, storing and searching information on tables.

Unit III

R Console; R Data types; R Vector creation using c (); R Assignment operators = <- ; R Arithmetic Operators; R Logical Operators; R Relational Operators;

Unit IV

R Matrix- Create, Print, Add Column using cbind (), Add Row using rbind (), Slice using [,]; R Data Frame - Create using data.frame (), Edit using edit (), Append using cbind (), rbind (), select (), subset (), sort using order (); List in R - Create using list (), Select; Data

Importing and Exporting in R Using read. table () and write. table (); install. packages (), library

Unit V

R script If, Else, Else If statements in R; For Loop and While Loop in R; Scatter Plot, Bar Chart and Histogram in R; Data Visualization with R ggplot2; Publishing Data Visualizations with R Shiny;

PRACTICALS

Implementation of Control Flow Statements, Looping Statements, Functions, Regular Expression, pattern matching and searching using regex. Validations using regular expressions. Python Database Interaction - SQL Database connection using python. Creating, Reading, storing and searching information on tables. R Console; R Vector creation using c(); R Assignment operators = <- ; R Matrix- Create, Print, Add Column using cbind(), Add Row using rbind(), Slice using [,]; R Data Frame - Create using data.frame(), Edit using edit(), Append using cbind(), rbind(), select(), subset(), sort using order(); List in R - Create using list(), Select; Data Importing and Exporting in R Using read.table() and write.table(); install.packages(), library(); Rscript, If, Else, Else If statements in R; For Loop and While Loop in R; Scatter Plot, Bar Chart and Histogram in R; Data Visualization with R ggplot2; Publishing Data Visualizations with R Shiny;

LECTURE SCHEDULE

Unit I

1 Introduction to Python – Identifiers, Keywords, Statements and Expressions
2 Operators, Precedence and Associativity, Data Types
3 Reading Input, Print Output, Type Conversions
4 Control Flow Statements, Looping Statements
5 Functions - Built-In Functions, Commonly Used Modules, Packages
6 Strings and Lists
7 Iterators

Unit II

8 Regular Expression
9 Pattern matching and searching using regex
10 Validations using regular expressions
11 Exception handling
12 Python Database Interaction - SQL Database connection using python
13 Creating, Reading, storing and searching information on tables.

Unit III

14 R Console; R Data types; R Vector creation using c();
15 R Assignment operators = <- ;
16 R Arithmetic Operators;
17 **Mid semester examination**

18 R Logical Operators;
19 R Relational Operators;

Unit IV

20 R Matrix- Create, Print,
21 Add Column using cbind(), Add Row using rbind(), Slice using [,];
22 R Data Frame - Create using data.frame (), Edit using edit(), Append using cbind (), rbind(),
23 Select (), subset(), sort using order();
24 List in R - Create using list(), Select;
25 Data Importing and Exporting in R Using read.table() and write.table();
26 install. packages(), library();

Unit V

27 Rscript
28 If, Else in R
29 Else If statements in R;
30 For Loop in R;
31 While Loop in R;
32 Scatter Plot, Bar Chart and Histogram in R;
33 Data Visualization with R ggplot2
34 Publishing Data Visualizations with R Shiny;

PRACTICAL SCHEDULE

1 Implementation of Control Flow Statements, Looping Statements, Functions
2 Regular Expression
3 Pattern matching and searching using regex
4 Validations using regular expressions
5 Python Database Interaction - SQL Database connection using python
6 Creating, Reading, storing and searching information on tables
7 R Console; R Vector creation using c(); R Assignment operators = <- ;
8 R Matrix- Create, Print, Add Column using cbind (), Add Row using rbind (), Slice using [,];
9 R Data Frame - Create using data. frame (), Edit using edit(), Append using cbind (), rbind (), select (), subset (), sort using order();
10 List in R - Create using list(), Select; Data Importing and Exporting in R Using read.table () and write. Table ();
11 Install. packages(), library(); Rscript,
12 If, Else, Else If statements in R;
13 For Loop in R; While Loop in R;
14 Scatter Plot, Bar Chart and Histogram in R;
15 Data Visualization with R ggplot2;
16 Publishing Data Visualizations with R Shiny;
17 **Final practical examination**

LEARNING OUTCOME

This course will impart knowledge on how to interpret and analyze data using R and Python programming.

SUGGESTED READING

1 Michael J. Crawley (2013). The R Book. 2nd Edition. John Wiley.
2 Robert Gentleman (2008). R Programming For Bioinformatics. Chapman and Hall/CRC
3 Brian S. Everitt and Torsten Hothorn (2009). A Handbook of Statistical Analyses Using R. Second Edition. Chapman and Hall/CRC
4 Bassi, S. (2017). Python for bioinformatics. Chapman and Hall/CRC.

SUGGESTED WEBSITES

1 https://www.python.org/doc/
2 https://www.r-project.org/other-docs.html
3 https://www.r-exercises.com/
4 RStudio.com Shiny Tutorial - https://shiny.rstudio.com/tutorial/ - https:// shiny. rstudio.com /articles/

MAT 501 MATHEMATICS FOR AGRICULTURAL ECONOMICS 2+1

WHY THIS COURSE?

This course provides a strong quantitative basis for the students to understand various Micro and Macroeconomic concepts

AIM OF THE COURSE

This course exposure student of Agricultural Economics to calculus and its applications in Agricultural Economics. It covers applications of Differential calculus, Integral calculus and Differential equations. This course provides a strong quantitative basis for the students to understand various Micro and Macro economic concepts.

THEORY

Unit I

Matrices – types - algebra of matrices. Determinants – properties - solution of simultaneous equations. Inverse of a matrix. Caylay Hamilton theorem- Eigen values and Eigen vectors.

Unit II

Definition and examples of variables and functions- basic theorems on limits and continuity (without proof). Revision of methods of differentiation. Maxima and minima of single. Application of differentiation - Elasticity of demand in terms of differentiation.

Average and marginal functions. Cost and Revenue curves- relationship. Conditions for profit maximization, Effects of taxation and subsidy.

Unit III

Revision of Partial differentiation - Maxima and minima of several variables with and without constraints -Marginal demands, partial elasticitics and utility analysis. Theory of consumer behavior- Rate of commodity substitution, Maximization of utility – slut sky equation (Income and substitution effects). Production functions and their mathematical properties- Isoquants and Ridge lines- Least cost combination – Constrained profit Maximization- Properties of linear homogenous functions- Euler's theorem.

Unit IV

Definite integrals, methods of integration definite integral; - Capital formation. Present value of continuous equal income stream. Consumer's and producer's surplus.

Unit V

Differential equations-meaning-types of differential equations-order and degree of the differential equations-formation and solution of first order and first degree linear differential equations . Solution of linear homogeneous equations. Applications in Micro economics – Utility and Demand analysis- Cost functions, Market equilibrium Harood Domor model, basic neo classic models, Solow models Domar debit models and some further applications**.**

PRACTICALS

Problems in algebra of matrices and determinants, simultaneous equation, eigen values and eigen vectors, simple differentiation, maxima and minima for single variables. Application of differentiation in Agricultural Economics. Simple problems in partial differentiation & Maxima and minima for several variables, Maxima and minima for several variables with constraints-Lagrange's method, Application of partial differentiation in agricultural economics, simple integral, calculation of consumer's and producer's surplus, formation of differential equation, solution of first order and first degree linear differential, solution of linear homogeneous equations.

LECTURE SCHEDULE

Unit I

1 Matrices – types of matrices, Algebra of matrices and determinant
2 Inverse of a matrix, Solution of simultaneous linear equations
3 Caylay Hamilton theorem
4 Eigen Values and Eigen Vector

Unit II

5 Definition and examples of variables and functions
6 Basic theorems on limits and continuity (without proof).
7 Revision and Simple Problems in differentiation

8 Maxima and minima of function of single with out constraints
9 Definitions of Elasticity, Total average and Marginal cost curve – relations
10 Total average and Marginal Revenue curves – Conditions for profit maximization

Unit III

11 Revision and Simple Problems in partial differentiation.
12 Maxima and minima of function of several variables – without constraints
13 Maxima and minima of function of several variables – with constraints - Lagrange's Multiplier's method
14 Partial elasticties and utility Analysis - Theory of consumer behavior
15 Rate of commodity substitution
16 **Mid semester examination**
17 Maximization of utility
18 Slutsky equation (Income and substitution effects).
19 Production functions and their mathematical properties
20 Isoquants and Ridge lines
21 Least cost combination Constrained profit Maximization
22 Properties of linear homogeneous functions - Euler's theorem

Unit IV

23 Definite integrals and their geometrical applications
24 Capital formation - Capital growth equation
25 Present value of continuous equal income stream
26 Calculations of consumer's and producer's surplus

Unit V

27 Solution of first order differential equations and Homogeneous
28 Linear differential equation with constant coefficients
29 Applications in Micro economics – Utility and Demand analysis
30 Applications in Micro economics - Cost functions, , Market equilibrium
31 Applications in Macro growth economics - Dynamic multiplier models
32 Applications in Macro growth economics - Harood Domor model
33 Applications in Macro growth economics - Basic neo classic models
34 Applications in Macro growth economics - Solow models Domar debit models

PRACTICAL SCHEDULE

1 Simple Problems in Matrices, Inverse Matrix
2 Problems in Solution of simultaneous linear equations
3 Problems in cayley Hamilton
4 Problems in Eigen value and Eigen verctor
5 Simple Problems in Differentiation
6 Maximum and minimum of function of single variables without constraints
7 Problems in Elasticity, Total average and Marginal cost/Revenue curves

8 Problems in Marginal demands, Partial elasticties and utility Analysis.
9 Simple Problems in partial differentiation
10 Maximum and minimum of function of several variables without constraints
11 Maximum and minimum of function of several variables with constraints
12 Problems in Maximization of utility and slut sky equation (Income and substitution effects) and Constrained profit Maximization
13 Homogeneous functions and Euler's theorem on homogenous functions
14 Problems in Definite integrals – geometrical applications
15 Calculations of consumer's and producer's surplus
16 Problems in Homogeneous, Linear differential equations
17 **Final practical examination**

LEARNING OUTCOME

Students can get exposure in basic knowledge in set theory, cost curve, supply curves and asticity with the applications in Agricultural Economics. Students can know to solve macro and micro economic models. Also this course provides a strong quantitative basis for the students to understand various Micro and Macro economic concepts

SUGGESTED READING

1 Metha, B.C. and Madani, G.M.K. (Reprint2008) Mathematics for Economists, Sultan Chand & Sons Educational Publishers, New Delhi.

2 ArumugamS. And Thangapandi Isaac (2002), Advanced Calculus, New Gamma Publishing house, Chennai.

SUGGESTED WEBSITES

1 http://en.wikipedia.org/wiki/Set_theory mathworld.wolfram.com /Newtons Divided Difference Interpolation Formula.html
2 http://en.wikipedia.org/wiki/Taylor_series

STA 501 STATISTICAL METHODS FOR APPLIED SCIENCES 2+1

WHY THIS COURSE?

- This course will help the students
- To study the exploratory data analysis
- To understand the various probability distributions and their application in their respective fields
- To perform the parametric and non-parametric tests based on the data
- To learn the relationship of the variables using correlation and regression techniques

AIM OF THE COURSE

The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, parametric and non-parametric tests, selection of sampling techniques and correlation, regression and ANOVA techniques.

THEORY

Unit I

Descriptive Statistics: Measure of Central Tendency, Measure of Dispersion, Skewness and Kurtosis for raw data only. Graphical and Diagrammatical representation: Bar Chart, Pie Chart, Frequency curve, Box Plot. Theory of Probability: axioms and properties, Addition and Multiplication Theorems on probability, Random Variable and Mathematical Expectation.

Unit II

Discrete and continuous probability distribution: Binomial, Poisson, Normal Distribution. Sampling theory: Population, parameter, sample and statistics; Sampling, need for sampling; Probability sampling: Simple random sampling (SRS), stratified random sampling, systematic sampling, cluster sampling; Non Probability sampling: Purposive and judgment sampling.

Unit III

Sampling distribution: Standard error and its uses, chi-square, t and F distributions. Theory of Estimation: Point Estimation, properties of good estimators; Properties of good estimators – unbiasedness, consistency, efficiency and sufficiency. Interval estimation: confidence limit, confidence interval. Test of significance based on Normal, t, F and Chi-square distributions.

Unit IV

Correlation and Regression: Correlation, types of correlation, pearson's correlation, testing the significance of correlation coefficient, rank correlation. Simple linear regression: assumption and fitting of simple linear regression, testing and interpretation of regression coefficient, coefficient of determination. Multiple linear regression and testing of coefficients.

Unit V

Introduction to ANOVA: One Way and Two way ANOVA. Non-parametric test: Sign test, Wilcoxon Test, Mann-Whitney U-test, Run test for the randomness of the sequence, Median test, Kruskalwallis test, Friedman's test.

PRACTICAL

Descriptive Statistics: Measure of central tendency, Measure of dispersion, Skewness and Kurtosis for raw data. Graphical and diagrammatical representation, Problems on Binomial, Poisson, Normal Distribution. Confidence interval estimation, Large sample test – testing mean and proportion, t-Test for single mean and two means, F-test for two variance, Test based on chi-square distributions. Correlation and Regression analysis. One Way ANOVA and Two way ANOVA. Non Parametric test: Wilcoxon Test, Mann-Whitney U-test, Run test for the randomness of the sequence, Median test, Kruskalwallis test, Friedman's test

LECTURE SCHEDULE

Unit I

1 Descriptive Statistics: Measure of central tendency for raw data
2 Descriptive Statistics: Measure of dispersion for raw data
3 Skewness and Kurtosis for raw data
4 Graphical and diagrammatical representation – Bar Chart, Pie Chart, frequency curve, Box Plot
5 Theory of Probability: axioms and properties, Addition and Multiplication Theorems on probability
6 Random Variable and Mathematical Expectation

Unit II

7 Discrete distribution: Binomial distribution
8 Discrete distribution: Poisson distribution
9 Continuous probability distribution: Normal Distribution
10 Sampling theory: Population, parameter, sample and statistics; Sampling, need for sampling
11 Probability sampling: Simple random sampling (SRS) – with and without replacement
12 Probability sampling: stratified random sampling and its method of allocation, Systematic sampling, cluster sampling
13 Non Probability sampling: Purposive and judgment sampling

Unit III

14 Sampling distribution: Standard error and its uses, chi-square, t and F distributions
15 Theory of Estimation: Point Estimation, Properties of good estimators: unbiasedness, consistency, efficiency and sufficiency
16 Interval estimation: confidence limit, confidence interval for single and two sample mean (t and Z)
17 **Mid Semester Examination**
18 Test of significance based on Normal distribution
19 Test of significance based on t distribution
20 Test of significance based on F distribution

21 Test of significance based on chi-square distributions

Unit IV

22 Correlation, Types of correlation, Pearson's correlation and its properties

23 Rank correlation

24 Simple linear regression: assumption and fitting of simple linear regression

25 Testing and interpretation of regression coefficient, coefficient of determination

26 Multiple linear regression model – Matrix approach and

27 Testingthe significance of correlation coefficient and regression coefficients, coefficient of determination

Unit V

28 Introduction to ANOVA: One Way ANOVA

29 Two way ANOVA

30 Introduction to Non-parametric test: Sign test

31 Wilcoxon Test, Mann-Whitney U-test

32 Run test for the randomness of the sequence, Median test

33 Kruskalwallis test

34 Friedman's test

PRACTICAL SCHEDULE

1 Descriptive Statistics: Measure of central tendency, Measure of dispersion, Skewness and Kurtosis for raw data.

2 Graphical and diagrammatical representation – Bar Chart, Pie Chart, frequency curve, Box Plot

3 Problems on Binomial distribution, Poisson distribution

4 Problems on Normal Distribution

5 Confidence interval estimation for single and two sample mean (t and Z)

6 Large sample test – testing mean and proportion of single and two sample

7 t-Test for single mean, two means (paired t-test)

8 t-Test for two means (independent t-test), F-test for two variance

9 Test of significance based on chi-square distributions

10 Correlation and testing of correlation coefficient

11 Regression analysis and testing the significance of regression coefficient

12 One Way ANOVA and Two way ANOVA

13 Wilcoxon Test, Mann-Whitney U-test

14 Run test for the randomness of the sequence, Median test

15 Kruskalwallis test

16 Friedman's test

17 **Practical Examination**

LEARNING OUTCOME

After successful completion of the course the students will be able to understand the exploratory data analysis, sampling and probability distribution, perform parametric and non parametric tests, well versed with regression and correlation analysis.

SUGGESTED READING

1 Goon A M, Gupta MK and Das Gupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.

2 Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley

3 Hogg RV and Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan

4 Robert V. Hogg, Joseph W. McKean, Allen T. Craig (2012). Introduction to Mathematical Statistics (7th Edition)

5 Siegel S, Johan N and Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley

6 Gupta. S.P, 2005, Statistical Methods, Sultan Chand & Sons, New Delhi

7 Rangaswamy, R, 2009, A text book of Agricultural Statistics, New Age International (P) Ltd., New Delhi.

8 K.P. Dhamu and K. Ramamoorthy, 2007, Statistical Methods, Agrobios (India), Jodhpur.

9 R. GangaiSelvi and C. Kailasam, 2017, Applied Statistics, Kalyani Publishers, New Delhi.

SUGGESTED WEBSITES

1 https://online.stat.psu.edu/statprogram/statistical%20methods

2 https://home.iitk.ac.in/~kundu/Statistical-Methods.pdf

3 https://www.nature.com/subjects/statistical-methods

4 https://sccn.ucsd.edu/~arno/mypapers/statistics.pdf

5 https://www.sciencedirect.com/book/9780123749703/statistical-methods

STA 502 DESIGN OF EXPEREIEMNTS 2+1

AIM OF THE COURSE

Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to various Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

THEORY

Unit I

Need for designing of experiments, Characteristics of good design. Basic principles of designs- randomization, replication and local control. Uniformity trails, size and shape of plots and blocks – determination of optimum plot size.

Unit II

Analysis of Variance, Data Transformation – Logrithmic, angular and square root transformation. Multiple comparison procedures – Least significant difference and Duncan's multiple range test. Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial Experiments: 2^n and 3^n factorial experiments, analysis using regular method, Yates algorithm (2^n, upto three factors), Asymmetric factorial experiments (upto three factors). orthogonality and partitioning of degrees of freedom. Concept of confounding in symmetric factorial experiments, complete and partial confounding. Split plot and strip plot designs.

Unit IV

Missing plot techniques in randomized block design and Latin square designs. Analysis of covariance.

Unit V

Balanced Incomplete Block Design (BIBD), Partially Balanced Incomplete Block Design (PBIBD), Lattice design, alpha design: concept, randomization procedure, analysis and interpretation. Introduction to resolvable designs and their applications. Combined analysis. Response surface design.

PRACTICAL

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments; Analysis of covariance; Analysis with missing data; Data transformation - Split plot and strip plot designs - Analysis of data obtained from BIBD, PBIBD.

LECTURE SCHEDULE

Unit I

1. Introduction to principles of Experimental designs; need for designing of experiments
2. Characteristics of good design
3. Basic principles of designs- randomization, replication and local control.
4. Uniformity trails, size and shape of plots and blocks – determination of optimum plot size

Unit II

5. Analysis of Variance
6. Data Transformation – Logrithmic and angular transformation
7. Square root transformation
8. Multiple comparison procedures – Least significant difference and Duncan's multiple range test

9. Completely randomized design: Layout, randomization, analysis, advantage and disadvantage
10. Randomized block design: Layout, randomization, analysis, advantage and disadvantage
11. Latin square design: Layout, randomization, analysis, advantage and disadvantage
12. Introduction to Factorial Experiments and its type

Unit III

13. 2^n factorial experiments using regular method (up to three factors)
14. 3^n factorial experiments using regular method (up to three factors)
15. Yates algorithm: 2^n factorial experiments (up to three factors)
16. Asymmetric factorial experiments (up to three factors)
17. **Mid Semester Examination**
18. Orthogonality : orthogonal Latin squares, Mutually orthogonal Latin squares (MOLS)
19. Partitioning of degrees of freedom
20. Concept of confounding in symmetric factorial experiments (in 2^3 factorial), advantage and disadvantage
21. Complete and Partial confounding (in 2^3 factorial)
22. Split plot designs: Layout, Randomization, Analysis, Advantage, Disadvantage.
23. Strip plot designs: Layout, Randomization, Analysis, Advantage, Disadvantage

Unit IV

24. Missing plot techniques in randomized block design – one and two missing observation
25. Missing plot techniques in Latin square designs. – one missing observation
26. Analysis of covariance (with one covariate)

Unit V

27. Balanced Incomplete Block Design (BIBD) – concept, randomization procedure
28. Balanced Incomplete Block Design (BIBD) – analysis and interpretation
29. Partially Balanced Incomplete Block Design (PBIBD): concept, randomization procedure, analysis and interpretation.
30. Introduction to Lattice design: Square lattice design, randomization, analysis and their application
31. Introduction to Alpha design: concept, randomization procedure, analysis and interpretation.
32. Introduction to resolvable designs and their applications.
33. Concepts of Combined analysis.
34. Response surface design and application: second order response surface design

PRACTICAL SCHEDULE

1. Uniformity trial data analysis
2. Formation of plots and blocks
3. Fairfield Smith Law

4. Analysis of data obtained from CRD
5. Analysis of data obtained from RBD
6. Analysis of data obtained from LSD
7. Data transformation: logarithmic, angular transformation
8. Square root transformations
9. Analysis with missing data (RBD one missing value only)
10. Analysis of factorial experiments - symmetrical
11. Analysis of factorial experiments - symmetrical
12. Split plot design
13. Strip plot design
14. Analysis of covariance in case of RBD
15. Analysis of data generated from a BIB design
16. Analysis of data generated from a PBIB design
17. **Final practical examination**

SUGGESTED READING

1. Cochran WG and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
2. Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.
3. Douglas C. Montgomery (2012). Design and Analysis of Experiments, 8th Ed. John Wiley.
4. Federer WT. 1985. Experimental Designs. MacMillan.
5. Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
6. Nigam AK and Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
7. Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley
8. Gomez, K.A. and Gomez, A.A., 1993, Statistical Procedures for Agricultural Research, John Wiley & Sons, New Delhi.
9. Rangaswamy, R, 2009, A text book of Agricultural Statistics, New Age International (P) Ltd., New Delhi.
10. K.P. Dhamu and K. Ramamoorthy, 2007, Statistical Methods, Agrobios (India), Jodhpur.

SUGGESTED WEBSITES

1. www.drs.icar.gov.in
2. https://www.moresteam.com/toolbox/design-of-experiments.cfm
3. https://www.coursera.org/specializations/design-experiments
4. https://online.stat.psu.edu/statprogram/stat503
5. https://www.labmanager.com/laboratory-technology/online-resources-for-experimental-design-21103

M.Sc. (Agri.) Genetics and Plant Breeding

M.Sc. (Agri.) Genetics and Plant Breeding

Sl No.	Course code	Course Title	Cr. Hr.
Major Courses			
01	GPB 501*	Principles of Genetics	2+1
02	GPB 502*	Principles of Plant Breeding	2+1
03	GPB 503*	Fundamentals of Quantitative Genetics	1+2
04	GPB 504	Varietal Development and Maintenance Breeding	1+1
05	GPB 505	Principles of Cytogenetics	2+1
06	GPB 506*	Molecular Breeding and Bioinformatics	2+1
07	GPB 507	Breeding for Quality and Special Traits	2+1
08	GPB 508	Mutagenesis and Mutation Breeding	2+1
09	GPB 509	Hybrid Breeding	2+1
10	GPB 510	Seed Production and Certification	1+1
11	GPB 511	Crop Breeding-I(Kharif Crops)	2+1
12	GPB 512	Crop Breeding-II(Rabi Crops)	2+1
13	GPB513	Breeding Vegetable Crops	2+1
14	GPB 514	Breeding Fruit Crops	2+1
15	GPB 515	Breeding Ornamental Crops	2+1
16	GPB 516	Breeding for Stress Resistance and Climate Change	2+1
17	GPB 517	Germplasm Characterization and Evaluation	1+1
18	GPB 518	Genetic enhancement for PGR Utilization	1+1
Seminar and Research			
1.	GPB 591	Seminar	0+1
2	GPB 599	Research	0+30

* Courses to be compulsorily registered

Minor Courses Offered

Sl No.	Course code	Course Title	Cr. Hr.
01.	CRP 501	Principles of Plant Physiology I: Plant Water Relations and mineral nutrition	2+1
02.	CRP 502	Principles of Plant Physiology II: Metabolic Process and Growth Regulation	2+1
03.	CRP 504	Physiological and Molecular response of plants to abiotic stresses	2+1
04.	MBB 504	Techniques in Molecular Biology I	1+2
05.	MBB505	Omics and System Biology	2+1
06.	MBB 506	Plant Genetic Engineering	3+0
07.	MBB 509	Plant Tissue Culture	2+1
08.	SST 503	Seed Production Principles and Techniques in Field Crops	2+1
09.	SST 508	Post-Harvest Handling and Storage of Seeds	2+1
10.	SST 509	Seed Quality Testing and Enhancement	1+1
11.	PGR 503	Germplasm Characterization and Evaluation	1+1
12.	PGR 504	Genetic enhancement for PGR Utilization	1+1
13.	PGR 507	PGR Exchange and Quarantine	2+1

SEMESTER WISE DISTRIBUTION OF COURSES

SEMESTSER I

Sl.No.	Course No.	Course Title	Credits
I.	Major Courses to be registered		9
II.	Minor Courses to be registered		6
III.	Supporting Course		
1	STA 501	Statistical Methods for Applied Sciences	2+1
IV.	Common Courses		
1	PGS 501	Library and Information Services	0+1
2	PGS 503	Intellectual Property and its Management in Agriculture	1+0
3	PGS 504	Basic Concepts in Laboratory Techniques	0+1

SEMESTSER II

Sl.No.	Course No.	Course Title	Credits
I.	Major Courses to be registered		11 or 12
II.	Minor Courses to be registered		2 or 3
III.	Supporting Course		
1	STA 502	Design of Experiments	2+1
IV.	Common Courses		
1	PGS 502	Technical Writing and Communication Skill	0+1
2	PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

SEMESTER III

Sl.No.	Course No.	Course Title	Credits
1	GPB 591	Master's Seminar	0+1
2	GPB 599	Master's Research	0+15

SEMESTER IV

Sl.No.	Course No.	Course Title	Credits
1	GPB 599	Master's Research	0+15

MAJOR COURSES

GPB 501* **Principles of Genetics** **2+1**

WHY THIS COURSE?

Improve the students understanding on applied aspects of Genetics, principally plant breeding science and molecular biology.

AIM OF THE COURSE

To make the students understand the basic concepts of inheritance of genetic traits, helping them to develop their analytical, quantitative and problem solving skills from classical to molecular genetics.

THEORY

Unit I

Beginning of genetics; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance. Multiple alleles, Gene interactions. Sex determination, Dosage compensation, sex differentiation and sex-linkage, Sex-influenced and sex-limited traits; Penetrance and expressivity; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

Unit II

Mendelian population – Random mating population - Frequencies of genes and genotypes-Causes of change: Hardy-Weinberg equilibrium-assumptions, proof and testing, extention of Hardy-Weinberg equilibrium. Random and no-random mating, inbreeding, pedigree analysis and population analysis. Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

Unit III

Genetic fine structure analysis, Allelic complementation, Modern concept of genes-Split genes, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters. Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; types of mutation, molecular mechanism of mutation, classification of mutagens.

Unit IV

Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing. Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR-based cloning, positional cloning; Nucleic acid hybridization and immuno-chemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

Unit V

Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.

Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

PRACTICAL

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification - Electrophoresis – basic principles and running of amplified DNA - Extraction of proteins and isozymes – use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

LECTURE SCHEDULE

01. Beginning of genetics; Early concepts of inheritance,
02. Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.
03. Multiple alleles and Gene interactions.
04. Sex determination, Dosage compensation, sex differentiation
05. sex-linkage, Sex-influenced and sex-limited traits; Penetrance and expressivity;
06. Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes,
07. Somatic cell genetics, Extra chromosomal inheritance.
O8. Mendelian population – Random mating population and inbreeding
09. Frequencies of genes and genotypes- Causes of change: Hardy-Weinberg equilibrium-assumptions, proof and testing, extention of Hardy-Weinberg equilibrium.
10. Pedigree analysis and population analysis.
11. Nature, structure and replication of the genetic material;
12. Organization of DNA in chromosomes, Genetic code;
13. Protein biosynthesis.
14. Genetic fine structure analysis.
15. Allelic complementation, Modern concept of genes- Split genes, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.
16. Regulation of gene activity in prokaryotes;
17. Mid-semester Examination
18. Regulation of gene activity in Prrokaryotes and eukaryotes
19. Molecular mechanisms of mutation- repair and suppression
20. Types of mutation and classification of mutagen
21. Bacterial plasmids, insertion (IS) and transposable (Tn) elements;
22. Molecular chaperones and gene expression. RNA editing.
23. Gene isolation, synthesis and cloning, genomic and cDNA libraries,
2 4 . PCR-based cloning, positional cloning;
25. Nucleic acid hybridization and immuno-chemical detection;
26. DNA sequencing;
27. DNA restriction and modification,

28. Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).
29. Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.
30. Methods of studying polymorphism at biochemical and DNA level;
3 1 . Transgenic bacteria and bioethics;
32. Gene silencing;
33. Genetics of mitochondria and chloroplast.
34. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

PRACTICAL SCHEDULE

01. Problem solving on probability and Chi-square
02. Problems on gene interactions
03. Problems on gene interactions
04. Problems on gene interactions
05. Trihybrid analysis
06. Demonstration of genetic principles using laboratory organisms
07. Chromosome mapping using three point test cross
08. Tetrad analysis
09. Problems in population genetics
10. Induction and detection of mutations through genetic tests
11. DNA extraction
12. PCR amplification
13. Electrophoresis: basic principles and running of amplified DNA
14. Extraction of protein and isozymes
15. Detection of transgenes in the exposed plant material
16. Visit to transgenic glasshouse and learning the practical consideration
17. Final practical examination.

LEARNING OUTCOME

After passing out this course, the student will be able to know the difference between the genotype and phenotype, can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of chracters.

SUGGESTED READING

1. Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons.
2. Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ.
3. Russell PJ. 1998. *Genetics*. The Benzamin/Cummings Publ. Co. Snustad DP & Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley & Sons.
4. Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India.
5. Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs.
6. UppalS, Yadav R, Subhadra & Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar
7. Singh B D. 2009. Genetics. Kalyani Publishers (2nd Revised Edition)
8. Lewin B. 2008. Genes XII. Jones & Bartlett Publ. (International Edition) Paperback,

2018.
9. Snustad DP & Simmons MJ. 2006. Genetics. 4th Ed. John Wiley & Sons. 6th Edition.
10. Stansfield W.D.1991. Genetics. Schaum Outline Series Mc Graw Hill

GPB 502* Principles of Plant Breeding 2+1

WHY THIS COURSE?

Improve the student's skill in applied crop research by understanding the concepts in plant breeding.

AIM OF THE COURSE

To make the students understand the theoretical and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

THEORY

Unit I

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants-Centres of Origin, Agro-biodiversity and its significance. Pre breeding and Plant Introduction and role of Plant Genetic resources in Plant breeding. Reproduction systems and pollination systems in plant breeding.

Unit II

Heritability and genetic advance, genotype-environment interaction; General and specific combining ability effects and variances; Types of gene actions and implications in plant breeding; Components of phenotypic value and components of variance and implication in plant breeding. Self-incompatibility and male sterility in crop plants and their commercial exploitation.

Unit III

Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability. Breeding methods in self-pollinated crops. Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach).

Unit IV

Breeding methods incross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding-genetical and physiological basis of heterosis

and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

Unit V

Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection. Concept of plant ideotype and its role in crop improvement; Transgressive breeding. Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses. Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights

PRACTICAL

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance; Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops.

LECTURE SCHEDULE

01. History of Plant Breeding (Pre and post-Mendelian era);
02. Objectives of plant breeding, characteristics improved by plant breeding;
03. Patterns of Evolution in CropPlants- Centres of Origin of crop plants,
04. Agro-biodiversity and its significance.
05. Role of Plant Genetic resources in Plant breeding
06. Pre breeding and Plant Introduction and.
07. Reproduction systems and pollination systems in plant breeding.
08. Heritability and genetic advance, genotype-environment interaction;
09. General and specific combining ability effects and variances
10. Types of gene actions and implications in plant breeding
11. Components of phenotypic value and components of variance and implication in plant breeding. 12. Self-incompatibility in crop plants and their commercial exploitation
13. Male sterility in crop plants and their commercial exploitation.
14. Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection and nature of variability.
15. Breeding methods in self-pollinated crops. Pure line theory, pure line selection
16. Mass selection methods; Line breeding, pedigree,
17. bulk, backcross, single seed descent method and multiline method
18. Population breeding in self-pollinated crops (diallel selective mating approach).
19. Breeding methods incross pollinated crops; Population breeding-mass selection and ear-to-row methods;
20. S_1 and S_2 progeny testing, progeny selection schemes,
21. Recurrent selection schemes for intraand inter-population improvement
22. Development of synthetics and composites.
23. Hybrid breeding - genetical and physiological basis of heterosis and inbreeding,

24. Production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance
25. Seed production of hybrid and their parent varieties/inbreds.
26. Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection.
27. Concept of plant ideotype and its role in crop improvement;
28. Transgressive breeding.
29. Special breeding techniques- Mutation breeding;
30. Breeding for abiotic and biotic stresses.
31. Cultivar development- testing, release and notification,
32. Maintenance breeding,
33. Participatory Plant Breeding,
34. Plant breeders' rights and regulations for plant variety protection and farmers rights.

PRACTICAL SCHEDULE

01. Floral biology, Selfing and crossing techniques - rice
02. Floral biology, Selfing and crossing techniques - sorghum
03. Floral biology, Selfing and crossing techniques - pearl millet and maize
04. Floral biology, Selfing and crossing techniques - redgram
05. Floral biology, Selfing and crossing techniques - blackgram and greengram
06. Floral biology, Selfing and crossing techniques - cowpea and bengalgram
07. Floral biology, Selfing and crossing techniques - cotton
08. Floral biology, Selfing and crossing techniques - groundnut
09. Floral biology, Selfing and crossing techniques - sunflower
10. Floral biology, Selfing and crossing techniques - sesamum
11. Floral biology, Selfing and crossing techniques - sugarcane
12. Floral biology, Selfing and crossing techniques – guinea grass, napier grass and lucerne
13. Selection methods in segregating populations and evaluation of breeding material
14. Analysis of variance (ANOVA), Estimation of heritability and genetic advance
15. Maintenance of experimental records, learning techniques in hybrid seed production using male-sterility in field crops
16. Prediction of performance of double cross hybrid
17. **Final practical examination**

LEARNING OUTCOME

The students will understand the theoretical basis of plant breeding and exposure to practical breeding and will help them for applied research.

SUGGESTED READING

1. Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.
2. Chopra VL. 2001. Breeding Field Crops. Oxford & IBH.
3. Chopra VL. 2004. Plant Breeding . Oxford & IBH.
4. Gupta SK 2005. Practical Plant Breeding. Agribios.

5. Chahal GS and Gossal, SS.2002. Principles and Procedures of Plant Breeding
6. Biotechnological and Conventional approaches. Narosa Publishing.
7. George A .2012. Principles of Plant Genetics and Breeding.John Wiley & Sons.
8. Jain HK and Kharakwal MC .2004. Plant Breeding and –Mendelian to Molecular Approach, Narosa Publications New Delhi.
9. Roy D. 2003.Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House.
10. Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
11. Sharma JP.2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.
12. Simmonds NW.1990. Principles of Crop Improvement. English Language Book Society.
13. Singh BD. 2006.Plant Breeding. Kalyani Publ.
14. Pohlman JM & Bothakur DN. 1972. Breeding Asian Field Crops. Oxford & IBH.
15. Singh P. 2002. Objective Genetics and Plant Breeding. Kalyani Publ.
16. Singh P. 2006. Essentials of Plant Breeding. Kalyani Publ.
17. Singh S & Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.

GPB 503* **Principles of Quantitative Genetics** **1+2**

WHY THIS COURSE?

Make student handle larger population, understanding its genetics and to improve the analytical skill of the student.

AIM OF THE COURSE

To impart theoretical knowledge and computation skills regarding components of variation and variances, scales,mating design and gene effects.

THEORY

Unit I

Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect. Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.

Unit II

Basic concepts Hardy- Weinberg law - Frequencies of genes and genotypes-Causes of change: population size, differences in fertility and viability, migration and mutation, mating system – Applications of the Hardy-Weinberg law. Analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions.

Unit III

Designs for plant breeding experiments- principles and applications; Nature of gene action - additive, dominance, epistatic and linkage effects. Principles of Analysis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA. Comparison of means and variances for significance. Association analysis- Genotypic and phenotypic correlation, Path analysis

Unit IV

Mating designs- classification, Diallel, partial diallel, L × T, NCDs, and TTC; Concept of combining ability and gene action, G × E interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation, Bi-plot analysis. Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D^2, Generation mean analysis, Parent progeny regression analysis.

Unit V

QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection. Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

PRACTICAL

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D^2 analysis Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis – Parent - progeny regression analysis - Diallel analysis: Griffing's methods I and II - Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation - Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model – Shifted multiplicative model- Analysis and Selection of genotypes- Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

LECTURE SCHEDULE

1. Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters.
2. Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect.
3. Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.
4. Basic concepts Hardy- Weinberg law - Frequencies of genes and genotypes-Causes of change: population size, differences in fertility and viability, migration and mutation,
5. Mating system – Applications of the Hardy-Weinberg law. Analysis of continuous variation;
6. Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions.
7. Designs for plant breeding experiments- principles and applications;
8. Nature of gene action - additive, dominance, epistatic and linkage effects.
9. **Mid-semester Examination**
10. Principles of Analysis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA.
11. Comparison of means and variances for significance. Association analysis- Genotypic and phenotypic correlation, Path analysis
12. Mating designs- classification, Diallel, partial diallel, L × T, NCDs, and TTC; Concept of combining ability and gene action,
13. G × E interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation,
14. Bi-plot analysis. Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D^2, Generation mean analysis, Parent progeny regression analysis.
15. QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis;
16. Markers, Marker assisted selection. Approaches to apply MAS in Plant breeding - selection based on marker.
17. Simultaneous selection based on marker and phenotype - factors influencing MAS.

PRACTICAL SCHEDULE

1. Analysis of continuous variation – mean, variance, skewness and kurtosis
2. Use of computer software for analysis of continuous variation
3. Analysis and interpretation of variability parameters in non-replicated data
4. Analysis and interpretation of variability parameters in replicated data
5. Use of computer packages for designs
6. Use of computer packages for correlation and path analyses
7. Genotypic and phenotypic correlation analysis and interpretation
8. Path coefficient analysis and interpretation.

9. Analysis and interpretation of Index score and Metroglyph
10. D^2 analysis
11. D^2 analysis
12. Estimation of different types of heterosis, inbreeding depression and interpretation
13. Generation mean analysis- 5 parameter
14. Generation mean analysis- 6 parameter
15. Use of computer packages for matting designs
16. Diallel analysis-graphical analysis
17. Diallel Analysis - Numerical analysis
18. Diallel analysis - partial diallel
19. L x T analysis
20. Use of computer packages for GxE interaction
21. GxE interaction and stability analysis – Eberhart and Russell model
22. GxE interaction and stability analysis - AMMI
23. GxE interaction and stability analysis –GGE Biplot
24. Use of computer packages for linkage and QTL analysis
25. Scoring of alleles from gel-identification of polymorphic markers, estimation of PIC
26. Linkage analysis
27. QTL analysis
28. QTL analysis
29. QTL analysis
30. Use of computer packages for MAS
31. MAS-foreground and background selection
32. MAS-estimation of recurrent parent genome
33. Case studies of MAS
34. Case studies of MABC
35. **Final Practical examination**

LEARNING OUTCOME

The student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with various designs for analysis of genotypic and phenotypic variance and QTL mapping.

SUGGESTED READING

1. Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

2. Falconer DS & Mackay J. 1998. *Introduction to Quantitative Genetics*. Longman.

3. Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall.

4. Mather K & Jinks JL. 1983. *Introduction to Biometrical Genetics*.Chapman & Hall.

5. Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publ.

6. Naryanan SS & Singh P. 2007. *Biometrical Techniques in Plant Breeding.* KalyaniPubl.

7. Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. KalyaniPubl.

8. Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*.

Kalyani.
9. Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
10. Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

GPB 504 Varietal Development and Maintenance Breeding 1+1

WHY THIS COURSE?

Make students well acquainted with the techniques and procedures of varietal development, DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

AIM OF THE COURSE

To make students well acquainted with the techniques and procedures of varietal development, DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

THEORY

Unit I

Variety Development systems and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

Unit II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.

Unit III

Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified Seeds.

Unit IV

Quality seed production technology of self and cross-pollinated crop varieties *viz*. cereals and millets (wheat, barley, paddy, pearl millet, sorghum, maize and ragi etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, field pea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard);

Unit V

Quality seed production technology of self and cross-pollinated crop varieties *viz*. fibres (cotton/jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne). Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

PRACTICAL

Identification of suitable areas/locations for seed production-Ear-to-row method and nucleus seed production-Main characteristics of released and notified varieties, hybrids and parental lines- PGMS and TGMS-Identification of important weeds/objectionable weeds-Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops-Hybrid seed production technology of important crops-DUS testing and descriptors in major crops-Variety release proposal formats in different crops.

LECTURE SCHEDULE

1 Cultivar Development and Maintenance- Various nomenclatures used based on the origin and genetic background of the cultivar
2 Variety testing, release and notification systems in India
3 Variety testing, release and notification systems adopted in other countries
4 DUS testing for cultivars – DUS descriptors for cereals and pulses
5 DUS descriptors for oilseeds, fibre crops, forage crops and sugarcane
6 Importance of maintenance of genetic purity in cultivars- Genetic markers-Morphological and molecular markers
7 Factors influencing genetic deterioration of cultivars and safeguards during seed production
8 Mid-Semester examination
9 Maintenance of varieties in self-pollinated crops - isolation distance and other parameters
10 Maintenance of varieties in cross pollinated crops - isolation distance and other parameters
11 Principles of seed production - Methods of nucleus and breeder seed production.
12 Generation system of seed multiplication – Nucleus seed, breeder seed, foundation seed and certified seed
13 Quality seed production technology of self and cross-pollinated crop varieties of cereals and pulses
14 Quality seed production technology of self and cross pollinated crop varieties of oilseeds, fibre and forage crops
15 Seed certification procedures and Seed laws and acts
16 Plant variety protection regulations in India
17 Plant variety protection regulations in International systems

PRACTICAL SCHEDULE

1 Identification of suitable area for seed production: Norms

2 Methods for nucleus seed production in self-pollinated crops
3 Methods for nucleus seed production in cross-pollinated crops
4 Methods for nucleus seed production in clonally propagated crops
5 Varietal descriptors (Morphological traits) and their importance in seed production
6 Seed production of PGMS and TGMS hybrids
7 Identification of important weeds / objectionable weeds
8 Determination of isolation distance and planting ratios in different crops; Grow-out test for genetic purity analysis
9 Breeder and foundation seed production of Varieties and hybrids in Rice
10 Breeder and foundation seed production of Varieties and hybrids in maize
11 Breeder and foundation seed production of Varieties and hybrids in redgram
12 Breeder and foundation seed production of Varieties and hybrids in sunflower
13 Breeder and foundation seed production of Varieties and hybrids in cotton
14 Maintenance of parents / inbreds / male sterile lines /maintainers / restorers
15 DUS testing and descriptors in major crops
16 Variety release proposal formats in different crops
17 Final practical examination

LEARNING OUTCOME

Students will have complete knowledge on the various procedures linked with the development and release of variety. This course will also enable student how to maintain and multiply variety for large scale distribution. It will also make student acquainted with the seed laws and acts related to plant variety protection.

SUGGESTED READING

1 Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
2 Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.
3 McDonald MB Jr & Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
4 Poehlman JM &Borthakur D. 1969. Breeding Asian Field Crops. Oxford & IBH.
5 Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani. 2015.
6 Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.

SUGGESTED WEBSITE

1. www.fao.org
2. www.agricoop.nic.in
3. www.agri.nic.in

GPB 505 PRINCIPLES OF CYTOGENETICS 2+1

WHY THIS COURSE?

Acquaint the students with cell cycle and architecture of chromosome in prokaryotes and eukaryotes, special types of chromosomes, techniques for karyotyping. This course aims to impart knowledge of variations in chromosomes numbers and their structures.

AIM OF THE COURSE

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

THEORY

Unit I

Cell cycle and architecture of chromosome in prokaryotes and eukaryotes - Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere - artificial chromosome construction and its uses; Special types of chromosomes. Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping – Chromosome banding and painting - in situ hybridization and various applications.

Unit II

Structural and numerical variations of chromosomes and their implications; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Inter-varietal chromosome substitutions.

Unit III

Fertilization barriers in crop plants at pre and post-fertilization levels; In vitro techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid vs allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer.

Unit IV

Alien addition and substitution lines , creation and utilization; Apomixis , evolutionary and genetic problems in crops with apomixes. Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale, brassica, and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number.

Unit V

Gene transfer using amphidiploids and bridge species. Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

PRACTICAL

Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy : various types of microscopes - Preparing specimen for observation-Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on mitosis and meiosis in crop plants - Using micrometres and studying the pollen grain size in various crops - Pollen germination in vivo and in vitro - Demonstration of polyploidy.

LECTURE SCHEDULE

1 Cell cycle and mitosis
2 Architecture of chromosome in prokaryotes
3 Architecture of chromosome in eukaryotes - Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere
4 Cell division - meiosis
5 Artificial chromosome construction and its uses
6 Special types of chromosomes
7 Variation in chromosome structure: Evolutionary significance
8 Introduction to techniques for karyotyping and chromosome banding
9 Chromosome painting -in situ hybridization and various applications
10 Structural variations of chromosomes and their implications
11 Numerical variations of chromosomes and their implications
12 Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids and aneuploids
13 Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction
14 Evolutionary significance of chromosomal aberrations
15 Balanced lethal and chromosome complexes
16 Inter-varietal chromosome substitutions
17 Mid semester examination
18 Fertilization barriers in crop plants at pre-and post-fertilization levels
19 In vitro techniques to overcome the fertilization barriers in crops
20 Polyploidy and genetic consequences of polyploidization
21 Role of polyploids in crop breeding and evolutionary advantages of autopolyploid vs allopolyploids
22 Role of aneuploids in basic and applied aspects of crop breeding, their maintenance
23 Utilization of aneuploids in gene location, mapping and gene blocks transfer
24 Alien addition lines and Alien substitution lines, creation and utilization
25 Apomixis, evolutionary and genetic problems in crops with apomixes

26 Reversion of autopolyploid to diploids
27 Interspecific hybridization and allopolyploids.
28 Synthesis of new crops (wheat, triticale, brassica and cotton)
29 Hybrids between species with same chromosome number, alien translocations
30 Hybrids between species with different chromosome number
31 Gene transfer using amphidiploids, bridge species
32 Genome mapping in polyploids
33 Chromosome manipulations in wide hybridization – case studies
34 Production and use of haploids, dihaploids and doubled haploids in genetics and breeding

PRACTICAL SCHEDULE

1 Cytogenetics laboratory – laboratory practices, safety, glasswares, cleaning, chemicals used for fixation and staining
2 Preparation of fixatives and stains for light microscopy, permanent slide preparation techniques
3 Microscopy – types of microscopes, fixing of specimens for mitosis and meiosis
4 Mitosis in onion / Aloe vera
5 Measurement of mitotic chromosomes
6 Microscopy – Electron microscopy
7 Meiosis in maize / pearl millet/sorghum
8 Meiosis in pulse crops
9 Meiosis in oilseed crops
10 Meiosis in cotton
11 Chemicals used for dehydration, embedding and their properties and preparation for microtomy
12 Sectioning of specimens and Histo – cytological observations
13 Observing pollen grains of different crops for their morphology using micrometer
14 In vitro and in vivo germination of pollen grains
15 Cytogenetics of polyploid species- sugarcane
16 Cytogenetics of triploids- Bajra- napier hybrids
17 Final practical examination

LEARNING OUTCOME

The course will provide full knowledge to the student on the various procedures linked with cell development and chromosome structure and function. This course will also enable student how to tailor and utilize the variation in chromosome number and structures in the development and synthesis of new species and varieties.

SUGGESTED READING

1 Becker K and Hardin J.2004. World of the Cell. 5th Ed. Pearson Edu. 9th edition.
2 Charles,B. 1993. Discussions in Cytogenetics. Prentice Hall Publications.
3 Darlington CD and La Cour LF. 1969. The Handling of Chromosomes. George Allen & Unwin Ltd.
4 Elgin SCR.1995.Chromatin Structure and Gene Expression. IRLPress, Oxford.

5 Khush GS. 1973. Cytogenetics of aneuploids. Elsevier. 1 edition.
6 Gupta PK and Tsuchiya T. 1991.Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A.
7 Gupta PK. 2010. Cytogenetics. Rastogi Pubishers.
8 Johannson DA.1975. Plant Micro technique. McGraw Hill.
9 Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons
10 Roy D.2009. Cytogenetics. Alpha Science Intl Ltd.
11 Sharma AK and Sharma A.1988. Chromosome Techniques: Theory and Practice.
12 Singh RJ .2016. Plant Cytogenetics 3 rd Edition. CRC Press.
13 Sumner AT.1982. Chromosome Banding. Unwin Hyman Publ. 1 edition, Springer pub.
14 Swanson CP.1960. Cytology and Cytogenetics. Macmillan & Co.

SUGGESTED WEBSITE

1. http://data.kew.org/cvalues/
2. https://www.sciencedirect.com/topics/neuroscience/cytogenetics
3. https://www.k-state.edu/wgrc/publications/2007/8696.pdf

GPB 506* MOLECULAR BREEDING AND BIOINFORMATICS 2+1

WHY THIS COURSE?

Provide deep knowledge to the students on genotyping and kinds of markers including biochemical and molecular, mapping populations, allele mining.

AIM OF THE COURSE

To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding.

THEORY

Unit I

Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.), Functional markers; Mapping populations (F2s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

Unit II

Allele mining; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants; Marker-assisted backcross breeding for rapid introgression; Genomics- assisted breeding; Generation of EDVs; Gene pyramiding.

Unit III

Introduction to Comparative Genomics; Large scale genome sequencing strategies; Human genome project; Arabidopsis genome project; Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; chromatography & sequencing by Edman degradation & mass spectrometry; Endopeptidases; Nanotechnology

and its applications in crop improvement.

Unit IV

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc and commercial releases; Biotechnology applications in male sterility/hybrid breeding, molecular farming.

Unit V

Application of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights ; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary & secondary), implications in crop improvement. Data management of Plant Genetic Resources.

PRACTICAL

Requirements for plant tissue culture laboratory - Techniques in plant tissue culture - Media components and media preparation - Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations - Inoculation of explants, callus induction and plant regeneration - Standardizing the protocols for regeneration - Hardening of regenerated plants - Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit - Transformation using Agrobacterium strains - GUS assay in transformed cells / tissues - DNA isolation, DNA purity and quantification tests - Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship - Construction of genetic linkage maps using computer software - NCBI Genomic Resources, GBFF, Swiss Prot, Blast n / Blast p, Gene Prediction Tool, Expasy Resources, PUBMED & PMC, OMIM & OMIA, ORF finder, Comparative Genomic Resources - Map Viewer (UCSC Browser & Ensembl) Primer designing - Primer 3 / Primer BLAST.

LECTURE SCHEDULE

1 Genotyping, morphological and biochemical markers
2 DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc) and functional markers
3 Mapping populations (F2s, back crosses, RILs, NILs and DH)
4 Molecular mapping and tagging of agronomically important traits
5 Statistical tools in marker analysis
6 Allele mining
7 Marker-assisted selection for qualitative and quantitative traits
8 QTLs analysis in crop plants
9 Marker-assisted backcross breeding for rapid introgression
10 Genomics- assisted breeding
11 Generation of EDVs

12 Gene pyramiding
13 Introduction to Comparative Genomics
14 Large scale genome sequencing strategies
15 Human genome project; Arabidopsis genome project; Rice genome project
16 Comparative genomics tools
17 Mid semester examination
18 Introduction to proteomics; 2D gel electrophoresis
19 Introduction to chromatography & mass spectrometry
20 Sequencing by Edman degradation
21 Endopeptidases
22 Nanotechnology and its applications in crop improvement.
23 Recombinant DNA technology
24 Transgenes and method of transformation - vector-mediated gene transfer, physical methods of gene transfer
25 Selectable markers and clean transformation techniques
26 Production of transgenic plants in various field crops: cotton, wheat, maize and commercial releases
27 Production of transgenic plants in various field crops: soybean, oilseeds, sugarcane *etc* and commercial releases
28 Biotechnology applications in male sterility/hybrid breeding, molecular farming
29 Application of Tissue culture in molecular breeding
30 GMOs and related issues (risk and regulations). International regulations associated with GMO,
31 Biosafety issues of GMOs. Regulatory procedures for GMO in major countries including India; ethical, legal and social issues; Intellectual property rights
32 Introduction to bioinformatics: bioinformatics tools,
33 Biological data bases (primary & secondary), implications in crop improvement
34 Data management of Plant Genetic Resources.

PRACTICAL SCHEDULE

1 Requirements for plant tissue culture laboratory
2 Techniques in plant tissue culture; Media components and media preparation
3 Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations
4 Inoculation of explants, callus induction and plant regeneration
5 Standardizing the protocols for regeneration
6 Hardening of regenerated plants; Establishing a greenhouse and hardening procedures
7 Visit to commercial micropropagation unit
8 Transformation using Agrobacterium strains and GUS assay in transformed cells/tissues
9 DNA isolation, DNA purity and quantification tests
10 Gel electrophoresis of proteins and isozymes
11 PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship

12 Construction of genetic linkage maps using computer software
13 NCBI Genomic Resources, GBFF, Swiss Prot, Blast n / Blast p, Gene Prediction Tool
14 Expasy Resources, PUBMED & PMC, OMIM & OMIA, ORF finder
15 Comparative Genomic Resources: Map Viewer (UCSC Browser &Ensembl)
16 Primer designing- Primer 3 / Primer BLAST
17 Final practical examination

LEARNING OUTCOME

The knowledge of this course will enable the student to know about various molecular tools and approaches for genotyping and marker assisted breeding, intellectual property rights, bioinformatics tools and their uses in crop improvement.

SUGGESTED READING

1 Brown TA. 1991. Essential Molecular Biology: a practical Approach. Oxford university press ,2002, 2nd edition.
2 Azuaje F & Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics. John Wiley & Sons.
3 Chawala H.S. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.
4 Chopra VL & Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methods and Applications. Oxford & IBH.
5 Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
6 Hackett PB, Fuchs JA & Messing JW. 1988. An Introduction to Recombinant DNA Technology
7 Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.
8 Jollès P & Jörnvall H. 2000. Proteomics in Functional Genomics: Protein Structure Analysis.
9 Lewin B. 2017. Genes XII. Jones & Bartlett learning, 2017.
10 Robert NT and Dennis JG. 2010. Plant Tissue Culture, Development, and Biotechnology. CRC Press.
11 Sambrook J & Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
12 Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani Publ.
13 Watson J .2006. Recombinant DNA. Cold Spring harbor laboratory press.

SUGGESTED WEBSITE

1.http://base.dnsgb.com.ua/files/book/Agriculture/PlantBreeding/Plant-Molecular-Breeding.pdf
2. http://download.bioon.com.cn/upload/201105/28152813_8350.pdf
3. http://cdn.intechopen.com/pdfswm/40178.pdf

GPB 507 Breeding for Quality and Special Traits 2+1

WHY THIS COURSE?

To acquaint breeding for grain quality parameters in field crops and teach about the genetic engineering protocols for quality improvement: Biofortification in crops and Nutritional genomics and Second generation transgenics.

AIM OF THE COURSE

To provide insight into recent advances in improvement of quality traits in cereals, millets, legumes, oilseeds, forage and industrial crops using conventional and modern biotechnological Approaches

THORY

Unit I

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors. Nutritional improvement on human health. Breeding for grain quality parameters in rice such as colour, shape, size chemical characteristics: eating quality, Aroma, taste etc., and its analysis; Golden rice I, II andaromatic rice:

Unit II

Breeding strategies, achievements and application, Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for quality traits in wheat includes Grain protein content, Grain test weight, Wet gluten content, SDS-sedimentation volume, and Total starch content characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

Unit III

Breeding for quality improvement in Sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies. Breeding for quality improvement in Sugarcane and potato.

Unit IV

Breeding for quality improvement in pulses – Chickpea, pigeonpea, green gram and black gram cooking quality; Breeding for quality in oilseeds -groundnut**,** mustard, soybean, sesame, sunflower and minor oilseeds; Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton.

Unit V

Breeding for quality improvement in important forage crops for stay green traits palatability, chemical composition, and digestibility; Genetic resource management for sustaining nutritive quality in crops. Role of Genetic engineering in quality improvement of various crops, its protocols, Second generation transgenics. Biofortification in crops and

recent achievements.

PRACTICAL

Grain quality evaluation in rice; Correlating ageing and quality improvement in rice. Quality analysis in millets. Estimation of anti-nutritional factors like tannins in different varieties/hybrids. A comparison - Quality parameters evaluation in wheat, pulses and oilseeds. Evaluation of quality parameters in cotton, sugarcane and potato - Value addition in crop plants, Post-harvest processing of major field crops. Quality improvement in crops through tissue culture techniques. Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures. Successful example of application of MAS for quality trait in rice, mustard, maize etc.

LECTURE SCHEDULE

1. Nutritional improvement- A human perspective- Importance of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors
2. Nutritional improvement- Micronutrients and its significance
3. Plant sources for various nutritional requirements to humans and animals
4. Rice as a major source of food- Various quality parameters of rice
5. Genetics and Breeding for grain quality parameters in rice
6. Breeding for aromatic rice
7. Breeding rice for increasing its nutritional qualities- Golden rice, Iron& Zn rich rice
8. Molecular basis of quality traits and their manipulation in rice
9. Breeding for baking qualities in wheat
10. Wheat quality characters and breeding strategies
11. Molecular and cytogenetic manipulation for quality improvement in wheat
12. Breeding for quality improvement in sorghum and Pearlmillet
13. Breeding for quality improvement in barley and oats
14. Breeding strategies for quality improvement in Maize
15. Breeding concept and improvement for specialty corn and QPM
16. Breeding for quality improvement in Sugarcane and potato
17. **Mid semester examination**
18. Breeding for quality improvement in Chickpea and pigeonpea
19. Breeding strategies for quality improvement in green gram and black gram
20. Anti-nutritional factors in cereals, millets and Pulses
21. Anti-nutritional factors in oil seeds and other crops
22. Breeding for quality improvement in groundnut
23. Breeding strategies for quality improvement in mustard and soybean
24. Breeding for quality improvement in sesame
25. Breeding strategies for quality improvement in sunflower and minor oilseeds
26. Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops
27. Genetic manipulation for quality improvement in cotton
28. Breeding for quality improvement in important forage crops for stay green traits

29. Forage crops - Quality improvement in relation to animal health
30. Genetic resource management for sustaining nutritive quality in crops
31. Biofortification in crops and its importance
32. Genetic engineering protocols for quality improvement:
33. Achievements made in quality improvement of different crops
34. Nutritional genomics and Second generation transgenics.

PRACTICAL SCHEDULE

1. Methods to study the quality parameters in cereals
2. Methods to study the quality parameters in pulses
3. Methods to study the quality parameters in oilseeds
4. Methods to study the quality parameters in fibres
5. Methods to study the quality parameters in sugarcane and Potato
6. Assessing quality parameters in cereals and pulses-Biochemical analysis
7. Assessing quality parameters in oilseeds- Biochemical analysis
8. Estimation of anti-nutritional factors in pulses, oilseeds and forage crops
9. Understanding the genetics of major quality traits and identifying suitable breeding method: Cereals
10. Understanding the genetics of major quality traits and identifying suitable breeding method: other crops
11. Methods to study the quality parameters in forage crops
12. Application of MAS for quality trait in rice , maize *etc.,*
13. Genetic engineering strategies in quality improvement
14. Value addition in crop plants
15. Post-harvest processing of cereals and millets
16. Post-harvest processing of pulses and oilseeds
17. **Final practical examination**

LEARNING OUTCOME

The knowledge of this course will expose the student to know about various conventional and genetic engineering techniques for the improvement of quality characters in agricultural and horticultural field crops.

SUGGESTED READING

1. Chahal GS and SS Ghosal. 2002.Principles and procedures of plant breeding-Biotechnological and Conventional approaches, Narosa Publications.
2. Chopra VL. 1997. Plant Breeding. Oxford & IBH.
3. FAO 2001. Speciality Rices of the World - Breeding, Production and Marketing. Oxford & IBH,1 Nov 2001.
4. Ghosh P. 2004. Fibre Science and Technology. Tata McGraw Hill.
5. Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.
6. Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.
7. Singh BD. 1997. Plant Breeding. Kalyani Publ.

8. Singh RK, Singh UK & Khush GS. 2000. Aromatic Rices. Oxford & IBH.

GPB 508 Mutagenesis and Mutation breeding 2+1

WHY THIS COURSE?

Enable the students to learn about mutation, various methods of inducing mutations and their utilization in plant breeding

THEORY

Unit I

Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations; Detection of mutations. Paramutations in crops plants. Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations. Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects – RBE and LET relationships;

Unit II

Effect of mutations on DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Dosimetry - Objects and methods of treatment. Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects ; Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume

Unit III

Chemical mutagens: Classification – base analogues, antibiotics, alkylation agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation – direct and indirect action, comparative evaluation of physical and chemical mutagens.

Unit IV

Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras etc.; Observing mutagen effects in M_2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage *etc.*, Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation; Comparative evaluation of physical and chemical mutagens for creation

of variability in the some species- Case studies

Unit V

Use of mutagens in creating oligogenic and polygenic variations – Case studies ; In vitro mutagenesis – Callus and pollen irradiation; Handling of segregating M2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement etc.) in different crops; Procedures for micromutations breeding/polygenic mutations; Achievements of mutation breedingvarieties released across the world, problems associated with mutation breeding. Use of mutagens in Use of mutagens in genomics, allele mining, TILLING.

PRACTICAL

Precautions on handling of mutagens, Dosimetry-Studies of different mutagenic agents: Physical mutagens and Chemical mutagens - Learning on Radioactivity-Production source and isotopes at BRIT, Trombay - Learning about gamma chamber - Radiation hazards : Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes - Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens - Procedures in combined mutagenic treatments - Raising the crop for observation, Mutagenic effectiveness and efficiency - calculating the same from earlier literature - Study of M1 generation-Parameters - Study of M2 generation – Parameters - Mutation breeding in cereals and pulses-achievements made and an analysis - Mutation breeding in oilseeds and cotton-achievements and opportunities; • Mutation breeding in forage crops and vegetatively propagated crops - Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

LECTURE SCHEDULE

1. Mutation and its history
2. Nature and classification of mutations: spontaneous and induced mutations
3. Micro and macro mutations, pre and post adaptive mutations
4. Detection of mutations, Para mutations in crops plants
5. Radiobiology: mechanism of action of various radiations scattering and pair production) and their biological effects on mutations on
6. DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects
7. Dosimetry -Objects and methods of treatment ; Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects
8. Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume
9. Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action

10. Dose determination and factors influencing chemical mutagenesis.
11. Treatment methods for Physical mutagens
12. Treatment methods for Chemical mutagens
13. Causes of mutation – direct and indirect action
14. Comparative evaluation of physical and chemical mutagenic effects
15. Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras etc.
16. Observing mutagen effects in M2 generation ; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations.
17. **Mid semester Examination**
18. Mutations in traits with continuous variation; Factors influencing the mutant spectrum Learning on Radioactivity- Production source and isotopes at BRIT, Trombay, Lea
19. Comparative evaluation of physical and chemical mutagens for creation of variability.
20. Individual plant based mutation analysis and working out effectiveness and efficiency.
21. Studying M3genotype, type of mutagen and dose, pleiotropy and linkage etc. Case studies
22. Use of mutagens in creating oligogenic and polygenic variations – Case studies
23. In vitro mutagenesis – Callus and pollen irradiation
24. Handling of segregating M2 generations and selection procedures; Validation of mutants
25. Mutation breeding for disease resistance in different crops
26. Mutation breeding for insect resistance in different crops
27. Mutation breeding for quality improvement and others in different crops
28. Procedures for micro mutations breeding/
29. Procedures for polygenic mutations
30. Achievements of mutation breeding varieties released across the world
31. Use of mutagens in genomics
32. Problems associated with mutation breeding
33. Use of mutagens in TILLING
34. Use of mutagens in allele mining.

PRACTICAL SCHEDULE

1. Precautions on handling of mutagens
2. Dosimetry- Studies of different Physical mutagenic agents and gamma chamber
3. Dosimetry- Studies of different Chemical mutagens
4. Radiation hazards : Monitoring – safety regulations and safe transportation of radioisotopes
5. Visit to radio isotope laboratory; learning on safe disposal of radioisotopes
6. Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens

7. Procedures in combined mutagenic treatments
8. Raising the crop for observation; Calculating the mutagenic effectiveness and efficiency.
9. Study of M_1 and M_2 generation – Parameters
10. Mutation breeding in cereals-achievements and opportunities
11. Mutation breeding in pulses-achievements and opportunities
12. Mutation breeding in oilseeds - achievements and opportunities
13. Mutation breeding in cotton- achievements and opportunities
14. Mutation breeding in forage crops - achievements and opportunities
15. Mutation breeding in vegetatively propagated crops - achievements and opportunities
16. Procedure for detection of mutations for polygenic traits in M_2 and M_3 generations
17. **Final practical examination**

LEARNING OUTCOME

This course will make the student well versed with the process of mutation and its use in crop Improvement.

SUGGESTED READING

1. Alper T. 1979. Cellular Radiobiology. Cambridge Univ. Press, London.
2. Chadwick KH & Leenhouts HP. 1981. The Molecular Theory of Radiation Biology. Springer-Verlag.
3. Cotton R, Edkin E & Forrest S. 2000. Mutation Detection: A Practical Approach. Oxford Univ.Press.
4. International Atomic Energy Agency. 1970. Manual on Mutation Breeding. International Atomic Energey Agency, Vienna, Italy.
5. Shu QY, Forster BP and Nakagawa N .2012. Plant Mutation Breeding and Biotechnology. Gutecnberg Press Ltd. Rome Italy ISBN: 978-925107-022-2 (FAO).
6. Singh BD. 2003. Genetics. Kalyani Publ.
7. Strickberger MW. 2005. Genetics. 3rd Ed. Prentice Hall.

GPB 509 Hybrid Breeding 2+1

WHY THIS COURSE?

Expose the students with the basic concepts of hybrid varieties and various techniques for development of hybrids in crop plants and to give an overview of various kinds of male sterility and their utilization in hybrid seed production of important field crops.

AIM OF THE COURSE

To provide knowledge of understanding about mechanisms of heterosis and

its exploitation for yield improvement through conventional and biotechnological approaches.

THEORY

Unit I

Historical aspect of heterosis, nomenclature and definitions of heterosis ; Heterosis in natural population and inbred population; Evolutionary aspects - Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis

Unit II

Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/genetic stocks and inbreeds, their improvement for increasing heterosis

Unit III

Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self- pollinated, cross pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

Unit IV

Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid; Organellar heterosis and complementation

Unit V

Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed, mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

PRACTICAL

Characterization of male sterile lines using morphological descriptors - Restorer line identification and diversification of male sterile sources - Male sterile line creation in crop plants , problems in creation of CGMS system, ways of

overcoming them - Diversification and restoration - Success stories of hybrid breeding in Maize, Rice, pearl millet, Sorghum and Pigeon pea - Understanding the difficulties in breeding apomicts - Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters - Hybrid seed production in field crops – an account on the released hybrids, their potential, problems and ways of overcoming it - Hybrid breeding at National and International level, opportunities ahead.

LECTURE SCHEDULE

1. Historical concepts of Heterosis; Pre Mendelian and Post Mendelian ideas
2. Nomenclature, definitions and genetic basis of heterosis
3. Biochemical and physiological basis of heterosis
4. Evolutionary concepts of heterosis
5. Prediction of heterosis from various crosses
6. Biometrical aspects of heterosis*;* residual heterosis in F_2
7. Heterosis in natural population and crossbred population; Evolutionary aspects
8. Effects of inbreeding on heterosis in self pollinated crops
9. Effects of inbreeding on heterosis in cross pollinated crops
10. Effects of inbreeding on heterosis in asexually propagated crops
11. Development of inbred lines and evaluation
12. Different types of hybrids-single, double and multiple cross hybrids
13. Relationship between genetic distance and expression of heterosis
14. Fixation of heterosis in self, cross and often cross pollinated crops
15. Fixation of heterosis in asexually/clonally propagated crops, apomixes
16. Male sterility and use in heterosis breeding
17. **Mid semester examination**
18. Development of male sterile lines and diversification in self pollinated crops
19. Development male sterile lines and diversification in cross pollinated and asexually propagated crops
20. Development of restorers and maintainers and their diversification
21. Creation of male sterility through genetic engineering and its exploitation in heterosis
22. Maintenance, transfer and restoration of different types of male sterility
23. Use of self-incompatibility in development of hybrids
24. Development of in breds and parental lines- A, B and R lines – functional male sterility
25. Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids
26. Apomixis in fixing heterosis-concept of single line hybrid
27. Organellar heterosis and complementation
28. Hybrid breeding in Rice
29. Hybrid breeding in Wheat and Maize
30. Hybrid breeding in pearl millet, sorghum

31. Hybrid breeding in pigeon pea
32. Hybrid breeding in rape seed and mustard.
33. Hybrid breeding in sunflower and Castor
34. Hybrid breeding cotton

PRACTICAL SCHEDULE

1. Estimation of heterosis in self, cross and a sexually propagated crops
2. Male sterile systems in rice – Characterization of male sterile lines using morphological descriptors; restorer line identification and diversification of male sterile sources
3. Male sterile line characterization in maize; using morphological descriptors; restorer line identification and diversification of male sterile sources
4. Male sterile line characterization in pearl millet and sorghum; using morphological descriptors; restorer line identification and diversification of male sterile sources
5. Male sterile line characterization in pigeon pea, cotton; using morphological descriptors; restorer line identification and diversification of male sterile sources
6. Male sterile line creation in dicots comprising oilseeds, pulses and cotton
7. Male sterile line creation in crop plants; Problems in creation of CGMS system; ways of overcoming them Success stories of hybrid breeding in Maize
8. Understanding the difficulties in breeding apomicts
9. Hybrid seed production in field crops – an account on the released hybrids; their potential; Problems and ways of overcoming it - hybrid breeding at National and International level
10. Hybrid seed production in rice
11. Hybrid seed production in maize and wheat
12. Hybrid seed production in pearl millet & Sorghum
13. Hybrid seed production in pulses and Oilseeds
14. Hybrid seed production in Oilseeds
15. Visit to hybrid seed production plot of cereals and millets
16. Visit to hybrid seed production plot of pulses and oilseeds
17. **Final practical examination**

LEARNING OUTCOME

The student will be able to know about importance of heterosis, the various conventional and biotechnological approaches for the development of hybrids. This will also enable student to know about the use of male sterility in hybrid seed production of important field crops.

SUGGESTED READING

1. Frankel, R. 1983. Heterosis: Reappraisal of Theory and Practice. Springer Verlag. Berlin
2. Gowen, J.W. 1952. Heterosis. Iowa State College Press, Iowa
3. Rai,B. 1979. Heterosis Breeding . Agro Biological Publications, Delhi. 183p

4. Virmani S S. 1994. Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics", Springer-Verlag.

GPB 510 Seed Production and Certification 1+1

WHY THIS COURSE?

Impart knowledge on principles of seed production and certification

AIM OF THE COURSE

To impart knowledge on principles of seed production and certification. This will help the students to understand seed production practices and seed certification procedures in different crops.

THEORY

Unit I

Importance of seed as basic input in agriculture; Seed quality concept and importance; Generation system of seed multiplication -Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.

Unit II

Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production in self- and cross-pollinated crops; Hybrid seed production - system and techniques involved in Seed village concept; Organic seed production & certification.

Unit III

Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self & cross-pollinated cereals and millets.

Unit IV

Floral structure, pollination mechanism and methods and techniques of seed production in major pulses & oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor & Sunflower. Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibers. Hybrid-seed production techniques in major vegetatively propagated crops.

Unit V

Seed certification - history, concept, objectives ;Central seed certification board Seed certification agency / organization and staff requirement; Legal status - Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum

Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning and management of seed certification programs ; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

PRACTICAL

Planting design for variety - hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony - Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination - Pollen collection and storage methods, pollen viability and stigma receptivity - Pre- harvest sanitation, maturity symptoms, harvesting techniques - Visits to seed production plots - visit to seed industries - Planning for seed production: cost benefit ratio, seed multiplication ratio & seed replacement rate - General procedure of seed certification, identification of weed and other crop seeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting / threshing, processing and after processing for seed law enforcement – Specifications for tags and labels to be used for certification purpose.

LECTURE SCHEDULE

1. Importance of seed as basic input in agriculture; Seed quality concept and importance
2. Generation system of seed multiplication -Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply
3. Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration
4. Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance
5. Principles of seed production in self and cross-pollinated crops
6. Hybrid seed production - system and techniques involved in Seed village concept; Organic seed production & certification
7. Floral structure, pollination mechanism and seed production techniques in self- & cross-pollinated cereals
8. **Mid semester examination**
9. Floral structure, pollination mechanism and seed production techniques in self- & cross-pollinated cereals and millets
10. Floral structure, pollination mechanism and methods and techniques of seed production in major pulses - Varietal and hybrid seed production techniques in Pigeon pea
11. Floral structure, pollination mechanism and methods and techniques of seed production in major oilseeds- Varietal and hybrid seed production techniques in Mustard, Castor & Sunflower

12. Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres.
13. Hybrid-seed production techniques in major vegetatively propagated crops
14. Seed certification - history, concept, objectives ; Central seed certification board Seed certification agency / organization and staff requirement; Legal status - Phases of seed
15. certification , formulation, revision and publication of seed certification standards
16. Minimum Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning and management of seed certification programs
17. Eligibility of a variety for certification, area assessment, cropping history of the seed field

PRACTICAL SCHEDULE

1. Planting design for variety and hybrid seed production techniques in different field crops
2. Planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony in cereals, pulses and oilseeds
3. Identification of rogues and pollen shedders for seed certification in cereals, pulses and oilseeds
4. Hybrid seed production techniques: supplementary pollination, detasseling in Maize
5. Hybrid seed production techniques hand emasculation and pollination in Rice
6. Pollen collection and storage methods, pollen viability and stigma receptivity in cereals, pulses and oilseeds
7. Pre-harvest sanitation, maturity symptoms, harvesting techniques in cereals, pulses and oilseeds
8. Visits to seed production plots
9. Visit to seed industries
10. Planning for seed production: cost benefit ratio, seed multiplication ratio & seed replacement rate in cereals, pulses and oilseeds
11. General procedure of seed certification in cereals, pulses and oilseeds
12. Identification of weed and other crop seeds as per specific crops for seed certification in cereals, pulses and oilseeds
13. Field inspection at different stages of a different field crops and observations recorded on contaminants and reporting of results
14. Seed inspection and sampling, harvesting / threshing in cereals, pulses and oilseeds
15. Seed processing and after processing for seed law enforcement in cereals, pulses and oilseeds
16. Specifications for tags and labels to be used for certification purpose in cereals, pulses and oilseeds
17. **Final practical examination**

LEARNING OUTCOME

The student will be able to know about seed production of different crop varieties and hybrids, their processing, marketing and seed laws.

SUGGESTED READING

1. Agrawal PK and Dadlani M. 1987. Techniques in Seed Science and Technology, South Asian Publishers, Delhi.
2. Agrawal RL. 1997. Seed Technology, Oxford & IBH Publishing.
3. Anon, 1965. Field Inspection Manual and Minimum Seed Certification Standards, NSC Publication, New Delhi.
4. Anon.1999.Manual of Seed Certification procedures. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
5. Kelly AF. 1988. Seed Production of Agricultural Crops. John Wiley, New York. Mc.
6. Ramamoorthy K, Sivasubramaniam K and Kannan M.2006. Seed Legislation in India. Agrobios (India), Jodhpur, Rajasthan.
7. Singhal NC. 2003. Hybrid Seed Production in Field Crops, Kalyani Publications, New Delhi.
8. Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

GPB 511 Crop Breeding-I (*Kharif* Crops) 2+1

WHY THIS COURSE?

Expose the students to the botanical features, reproductive systems, genetics involved and Important breeding techniques of major kharif crops.

AIM OF THE COURSE

To provide insight into recent advances in improvement of *Kharif c*ereals, legumes, oilseeds, fibre, sugarcane and vegetative propagated crops using conventional and modern biotechnological approaches.

THEORY

Unit I

Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc., Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding. Maize:- Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement- QPM and Bt maize – strategies and implications. Sorghum, Pearl millet and Small millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and

genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance. Pseudocereals.

Unit II

Pigeonpea: evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes. Groundnut: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement Other pulses: Urdbean, mungbean, cowpea: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Soybean: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement Castor and Sesame: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s), released varieties, examples of MAS used for improvement; Hybrid breeding in castor – opportunities, constraints and achievements.

Unit IV

Cotton: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.; Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance,

heterosis breeding, released varieties, examples of MAS used for improvement.

Unit V

Sugarcane: Evolution and distribution of species and forms , wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc. – Forage crops: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance etc., Seed spices : Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc.,; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; Achievements of important spice crops.

PRACTICAL

Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton; Study of range of variation for yield and yield components ; Study of segregating populations in cereal, pulses and oilseed crops; Learning on the crosses between different species ; attempting crosses between black gram and green gram; Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton; Visit to Cotton Technology Laboratory and Spinning Mills ; Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval; Practical learning on the cultivation of fodder crop species on sewage water, analyzing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Visit to animal feed producing factories; Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

LECTURE SCHEDULE

1. Rice: evolution and distribution of species and forms - wild relatives and germplasm cytogenetics and genome relationship, Role of National and International Institute for rice improvement
2. Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, Application of Molecular marks in rice improvement.
3. Hybrid rice breeding: potentials and outcome : Aerobic rice, NERICA lines; its implications and drought, salinity and submergence tolerant breeding
4. Maize: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship, breeding objectives: Yield quality characters. Role of National and International Institute for Maize improvement.

5. Breeding for biotic and abiotic stress resistance. Marker Assisted Selection (MAS) in crop improvement, Significance of Quality Protein Maize and Bt maize – strategies and implication.
6. Sorghum: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship, male sterility, hybrid breeding, breeding objectives: yield, biotic, abiotic stress resistance and quality characters. Role of National and International Institute for Sorghum improvement. Pseudocereals.
7. Pearl millet: evolution and distribution of species and forms - wild relatives and germplasm cytogenetics and genome relationship, male sterility, hybrid breeding, breeding objectives: yield, quality characters, biotic and abiotic stress resistance and quality characters. Role of National and International Institute for Pearl Millet improvement.
8. Small millets: evolution and distribution of species and forms - wild relatives and germplasm cytogenetics and genome relationship
9. Small millets: breeding objectives: yield, quality characters, biotic and abiotic stress resistance.
10. Pigeonpea: evolution and distribution of species and forms - wild relatives and germplasm cytogenetics and genome relationship genetics; breeding objectives: yield, quality characters
11. Pigeonpea: biotic and abiotic stress resistance, Male sterility, Hybrid technology important varieties and seed production procedures. Role of National and International Institute for Pigeonpea improvement.
12. Groundnut: Origin, evolution and distribution of species and forms wild relatives and germplasm.
13. Groundnut: cytogenetics and genome relationship; breeding objectives: yield, and quality characters.
14. Groundnut: biotic and abiotic stress resistance Interspecific crosses, important varieties, seed production and hybrid breeding. Role of National and International Institute for Groundnut improvement.
15. Urdbean, mungbean and cowpea: Origin, evolution, cytogenetics and genome relationship, learning the descriptors
16. Urdbean, mungbean and cowpea: breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., important varieties, seed production and hybrid breeding
17. **Mid semester examination**
18. Soybean: origin, evolution and distribution of species and forms wild relatives and germplasm cytogenetics, genome relationship and Role of National and International Institute for Soybean improvement.
19. Soybean: breeding objectives: yield, quality characters, biotic and abiotic stress resistance, important varieties, seed production and hybrid technology

20. Castor and sesame: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship
21. Castor and sesame : breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., varieties and seed production
22. Cotton: Origin evolution, genetics - cytogenetics and genome relationship
23. Cotton: breeding objectives: yield, quality characters, biotic and abiotic stress; varieties and seed production
24. Hybrid cotton: Development and maintenance of male sterile lines – Hybrid development and seed production Bt cotton scenario in India Evaluation procedures for Bt cotton
25. Jute: evolution and distribution of species and forms - wild relatives and germplasm – cytogenetics and genome relationship
26. Jute: breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.
27. Sugarcane: evolution and distribution of species and forms - wild relatives and germplasm cytogenetics and genome relationship
28. Sugarcane: breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.
29. Forage grasses & Legumes : evolution and distribution of species and forms Wild relatives and germplasm - cytogenetics and genome relationship
30. Forage grasses & Legumes: breeding objectives: yield, quality characters and palatability studies biotic and abiotic stress etc., synthetics, composites and apomixis
31. Tree fodders: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship
32. Tree fodders: breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., palatability studies
33. Seed spices : Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship Breeding objectives : yield, quality characters
34. Seed spices, Breeding approaches, biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; Achievements of important spice crops

PRACTICAL SCHEDULE

1. Floral biology, emasculation, pollination techniques in rice
2. Floral biology, emasculation, pollination techniques in maize
3. Floral biology, emasculation, pollination techniques in pigeonpea
4. Floral biology, emasculation, pollination techniques in soybean
5. Floral biology, emasculation, pollination techniques in sesame
6. Floral biology, emasculation, pollination techniques in cotton
7. Study of range of variation for yield and yield components
8. Study of segregating populations in cereals

9. Study of segregating populations in pulses and oilseeds
10. Attempting crosses between black gram and green gram
11. Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton
12. Learning on the Standard Evaluation System (SES) and descriptors
13. Visit to Cotton Technology Laboratory and Spinning Mills; Learning on the Standard
14. Evaluation System (SES) and descriptors
15. Practical learning on the cultivation of fodder crop species on sewage water and analyzing them for yield components and palatability
16. Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Cytological studies in Cenchrus sp., Guinea grass and Cumbu Napier hybrids for their meiotic orientation and distribution to the gametes, interpretation
17. Visit to animal feed producing factories, learning the practice of value addition; visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder
18. Final practical examination

LEARNING OUTCOME

The student will be able to know about important botanical status and reproductive structures of crops and genetics of important *Kharif* field crops.

SUGGESTED READING

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN &Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.
3. Gill KS. 1991. Pearl Millet and its Improvement. ICAR.
4. Jennings PR, Coffman WR & Kauffman HE. 1979. Rice Improvement. IRRI, Los Banos, Manila, Philippines.
5. Nanda JS. 1997. Manual on Rice Breeding. Kalyani Publishers.
6. Poehlman, JM .1987. Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connecticut, USA.
7. Sharma, A K .2005. Breeding Technology of Crop Plant. Yesh Publishing House, Bikaner.
8. Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
9. Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.
10. Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons.

GPB 512 Crop Breeding-II (*Rabi* Crops) 2+1

WHY THIS COURSE?

Expose the students to the botanical features, reproductive systems, genetics involved and important breeding techniques of major Rabi crops.

AIM OF THE COURSE

To provide insight into recent advances in improvement of Rabi cereals, legumes, oilseeds, fibre and vegetative propagated crops using conventional and modern biotechnological approaches.

THEORY

Unit I

Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement **Oats:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement Barley: Origin, evolution, center of origin, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Unit II

Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc, breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.. Other pulses: Lentil, field pea, Field bean, Rajma, Horse gram: Origin, evolution, mode of reproduction, chromosome number; Genetics. Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc. breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Rapeseed and Mustard: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives; yield, quality characters, biotic and abiotic stress resistance etc., Breeding approaches, introgression of alien gene(s) (if required), , biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality Sunflower, Safflower: Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit IV

Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, 41 biotic and abiotic stress resistance etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V

Seed spices : Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc., breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, scope of heterosis breeding, released varieties, examples of MAS used for crop improvement.

PRACTICAL

Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea, rajma, rapeseed mustard, sunflower- Study of range of variation for yield and yield components; Study of segregating populations in cereal, pulses and oilseed crops - Use of descriptors for cataloguing; Learning on the crosses between different species - Trait based screening for stress resistance - Learning on the Standard Evaluation System (SES) and descriptors - Use of software for database management and retrieval.

LECTURE SCHEDULE

1. Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, Role of National and International Institute for Wheat improvement.

2. Wheat: Breeding objectives: yield, quality characters, biotic and abiotic stress resistance for wheat improvement.
3. Wheat: Breeding approaches and introgression of alien gene(s) from progenitor and non-progenitor species.
4. Wheat: Heterosis breeding, released varieties and examples of Marker Assisted Selection used for improvement
5. Oats: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship. Role of National and International Institute for Oats Improvement
6. Oats: Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc. Breeding approaches and introgression of alien gene(s)
7. Oats: Latest released varieties in India, World and examples of MAS used for improvement
8. Barley: Origin, evolution, center of origin, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, Role of National and International Institute for Barley Improvement
9. Barley: Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., Breeding approaches and introgression of alien gene(s)
10. Barley: Latest released varieties in India, World and examples of MAS used for improvement
11. Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, Role of National and International Institute for Chickpea Improvement
12. Chickpea: Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc., Breeding approaches and introgression of alien gene(s)
13. Chickpea: Latest released varieties in India, World and examples of MAS used for improvement
14. Lentil, field pea, field bean: Origin, evolution, mode of reproduction, chromosome number; Genetics. Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.
15. Lentil, field pea, field bean: Breeding approaches, introgression of alien gene(s); Heterosis breeding, released varieties and examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them
16. Rajma, Horse gram: Origin, evolution, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship. Breeding objectives : yield, quality characters, biotic and abiotic stress resistance etc
17. **Mid semester examination**
18. Rajma, Horse gram: Breeding approaches, introgression of alien gene(s) Heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them

19. Rapeseed and Mustard: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship
20. Rapeseed and Mustard: Breeding objectives; yield, quality characters, biotic and abiotic stress resistance etc.
21. Rapeseed and Mustard: Breeding approaches, introgression of alien gene(s), heterosis breeding, Released varieties, examples of MAS used for improvement
22. Rapeseed and Mustard: Oil quality and improvement for oil quality
23. Sunflower : Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship
24. Sunflower: Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc. Breeding approaches and introgression of alien gene(s)
25. Sunflower : Heterosis breeding, released varieties and examples of MAS used for improvement
26. Safflower: Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc. Breeding approaches, introgression of alien gene(s) heterosis breeding, released varieties and examples of MAS used for improvement
27. Mesta and minor fibre crops: Origin,, mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship
28. Mesta and minor fibre crops: Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc. Breeding approaches, introgression of alien gene(s), released varieties and examples of MAS used for improvement
29. Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship
30. Forage crops: Breeding objectives: yield, quality characters, 41 biotic and abiotic stress resistance etc., breeding approaches and introgression of alien gene(s); released varieties and examples of MAS used for improvement
31. Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship
32. Seed spices: Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.
33. Seed spices: Breeding approaches and introgression of alien gene(s)
34. Seed spices: Scope of heterosis breeding, released varieties and examples of MAS used for crop improvement

PRACTICAL SCHEDULE

1. Wheat: Floral biology, emasculation and pollination techniques - Study of range of variation for yield and yield components; learning on the crosses between different species
2. Wheat: Trait based screening for stress resistance. Learning on the Standard Evaluation System (SES) and use of descriptors for cataloguing
3. Oats: Floral biology, emasculation and pollination techniques - Study of range of variation for yield and yield components; Learning on the crosses between different

species ; Trait based screening for stress resistance Learning on the Standard Evaluation System (SES) and Use of descriptors for cataloguing

4. Barley : Floral biology, emasculation and pollination techniques - Study of range of variation for yield and yield components; Learning on the crosses between different species ; Trait based screening for stress resistance Learning on the Standard Evaluation System (SES) and Use of descriptors for cataloguing
5. Study of segregating populations in cereals
6. Chick pea: Floral biology, emasculation and pollination techniques - Study of range of variation for yield and yield components; Learning on the crosses between different species
7. Chick pea: Trait based screening for stress resistance. Learning on the Standard Evaluation System (SES) and Use of descriptors for cataloguing
8. Rajma: Floral biology, emasculation and pollination techniques - Study of range of variation for yield and yield components; Learning on the crosses between different species ; Trait based screening for stress resistance Learning on the Standard Evaluation System (SES) and Use of descriptors for cataloguing
9. Study of segregating populations in pulses
10. Rapeseed Mustard: Floral biology, emasculation and pollination techniques - Study of range of variation for yield and yield component
11. Rapeseed Mustard: Learning on the crosses between different species; Trait based screening for stress resistance
12. Rapeseed Mustard: Learning on the Standard Evaluation System (SES) and Use of descriptors for cataloguing
13. Sunflower: Floral biology, emasculation and pollination techniques - Study of range of variation for yield and yield components; Learning on the crosses between different species
14. Sunflower: Trait based screening for stress resistance learning on the Standard Evaluation System (SES) and Use of descriptors for cataloguing
15. Study of segregating populations in oilseed crops
16. Use of software for database management and retrieval
17. **Final practical examination**

LEARNING OUTCOME

The student will be able to know about the different breeding methods and genetics of major Rabi field crops.

SUGGESTED READING

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN &Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.
3. Gupta, S.K. 2016. Breeding of Oilseed Crops for Sustainable Production. Academic Press,USA.
4. Parthasarathy VA .2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of

Horticultural Crops Vol.1 (Part-B).
5. Poehlman JM .1987. Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connectcut, USA.
6. Sharma AK .2005. Breeding Technology of Crop Plant. Yesh Publishing House.
7. Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
8. Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.

GPB 513 Breeding Vegetable Crops 2+1

WHY THIS COURSE?

Enable the students to learn about breeding objectives, methodologies and genetics involved for the improvement of major vegetable crops.

AIM OF THE COURSE

To educate about principles and practices adopted for breeding of vegetable crops.

THEORY

Unit I

Introduction of Plant Breeding- Mode of reproduction and pollination control in vegetable crops -Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II

Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

Unit III

Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper

Unit IV

Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol- Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V

Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

PRACTICAL

Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm-Hybridization and handling segregating generations-Induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops-Hybrid seed production of vegetable crops in bulk-Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops-Demonstration of sib-mating and mixed population-Molecular marker

techniques to identify useful traits in the vegetable crops and special breeding techniques-Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

LECTURE SCHEDULE

1. Introduction to Plant Breeding
2. Genetics and cytogenetic principles involved in plant breeding
3. Mode of reproduction and pollination control in vegetable crops
4. Creation of variation and effect of selection in vegetable breeding
5. Special breeding approaches for vegetable breeding
6. Breeding methods for Leafy vegetables: amaranth
7. Breeding methods for chenopods
8. Breeding methods for lettuce
9. Breeding methods for Cucurbits: Ribbed gourd
10. Breeding methods for Cucurbits: Bitter gourd
11. Breeding methods for Ash gourd
12. Breeding methods for water melons
13. Breeding methods for musk melons
14. Breeding methods for pumpkins
15. Breeding methods for squashes
16. Breeding methods for Potato
17. **Mid semester examination**
18. Breeding methods for Tomato
19. Breeding methods for Chillies
20. Breeding methods for Brinjal
21. Breeding methods for Cabbage
22. Breeding methods for cauliflower
23. Breeding methods for broccoli
24. Breeding methods for knolkhol.
25. Breeding methods for Root vegetables: carrot
26. Breeding methods for beetroot
27. Breeding methods for radish
28. Breeding methods for sweet potato
29. Breeding methods for tapioca
30. Breeding methods for Peas
31. Breeding methods for beans
32. Breeding methods for onion
33. Breeding methods for garlic
34. Breeding methods for okra

PRACTICAL SCHEDULE

1. Selection of desirable plants from breeding population
2. Hybridization and handling of segregating generations

3. Observations and analysis of various qualitative and quantitative traits in germplasm, for Assessment of variability, genetic diversity, correlation and path analysis
4. Combining ability studies and Estimation of heterosis in vegetable crops
5. Study of pollination mechanisms, pollen morphology and viability in solanaceous vegetable Crop
6. Study of pollination mechanisms, pollen morphology and viability in cucurbits
7. Study of pollination mechanisms, pollen morphology and viability in crucifers
8. Floral biology and techniques of hybridization in solanaceous vegetables
9. Floral biology and techniques of hybridization in leguminous vegetables
10. Floral biology and techniques of hybridization in cucurbitaceous vegetables
11. Floral biology and breeding methods for cruciferous vegetable crops
12. Screening techniques for insect-pests resistance in vegetable crops
13. Screening techniques for disease resistance in vegetable crops
14. Screening techniques for environmental stress resistance in vegetable crops
15. Demonstration of sib-mating and mixed population.
16. Molecular marker techniques to identify useful traits in the vegetable crops
17. **Final practical examination**

SUGGESTED READING

1. Fageria, M.S., P.S. Arya. & A.K. Choudhary. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani Publ., New Delhi.
2. Gupta, S.K. 2000. Plant Breeding. Theory and Techniques. Vedam Publishers, Solan.
3. Kalloo, G. 1994. Vegetable Breeding – Combined Edition – Panima Book Publishers, New Delhi.
4. Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.

GPB 514 Breeding Fruit Crops 2+1

WHY THIS COURSE?

Enable the students to learn about breeding objectives, methodologies and genetics involved for the improvement of major fruit crops.

AIM OF THE COURSE

To educate the students about principles and practices adopted for breeding of fruit crops.

THEORY

Unit I

Fruit crop breeding: History, importance of fruit breeding, centers of diversity, distribution, domestication and adaptation of commercially important fruits.

Unit II

Issues in fruit crop breeding – heterozygosity, polyploidy, polyembryony, parthenocarpy and seedlessness, incompatibility & sterility systems.

Unit III

Apomixis - merits & demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.

Unit IV

Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate

Unit V

Crop improvement in Pine apple & Guava, Apple and other Rosaceous crops and region specific fruit crops.

PRACTICAL

Germplasm documentation - Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops - Pollen germination to study time of anthesis and stigma receptivity - Hybridization technique in important fruit crops, hybrid seed collection and raising - Colchicine treatment for induction of polyploidy - Exposure to resistance breeding & screening techniques - Mutation breeding practices raising and evaluation of segregating populations - Use of mutagens to induce mutations and polyploidy - Visit to Biotechnology Lab & study of in vitro breeding techniques.

LECTURE SCHEDULE

1. History and development of fruit breeding
2. Importance of fruit breeding
3. Centers of diversity and distribution
4. Domestication and adaptation of commercially important fruits
5. Issues in fruit breeding – heterozygosity
6. Issues in fruit breeding – polyembryony
7. Seedlessness
8. Polyploidy
9. Parthenocarpy
10. Incompatibility & sterility systems
11. Apomixis - merits & demerits, types
12. Genetic Variability for economic traits and its significance
13. Germplasm and its significance
14. Breeding strategies – Clonal selection
15. Breeding strategies – Bud mutations
16. Breeding Strategies – Chimeras
17. **Mid semester examination**
18. Breeding strategies – Mutagenesis and its application

19. Breeding strategies – hybridization and problems.
20. Resistance breeding for biotic stresses
21. Resistance breeding for abiotic stresses
22. Role of genetic engineering in improvement of fruit Crops
23. Role of biotechnology in improvement of fruit Crops
24. Crop improvement in Mango
25. Crop improvement in Banana
26. Crop improvement in Citrus
27. Crop improvement in Grapes
28. Crop improvement in Papaya
29. Crop improvement in Sapota
30. Crop improvement in Pomegranate
31. Crop improvement in Pineapple
32. Crop improvement in Guava
33. Crop improvement in Apple and other rosaceous crops
34. Crop improvement in Region specific fruit crops

PRACTICAL SCHEDULE

1. Germplasm documentation
2. Floral biology and hybridisation techniques in Mango
3. Floral biology and hybridisation techniques in Guava
4. Floral Biology and hybridisation techniques in Citrus
5. Floral Biology and hybridisation techniques in Grapes
6. Floral Biology and hybridisation techniques in Pomegranate
7. Floral Biology and hybridisation techniques in Papaya
8. Floral Biology and hybridisation techniques in Sapota and banana
9. Pollen Viability in major fruit crops
10. Pollen germination to study time of anthesis and stigma receptivity
11. Colchicine treatment for induction of polyploidy
12. Exposure to resistance breeding & screening techniques for biotic resistance
13. Exposure to resistance breeding & screening techniques for abiotic resistance
14. Mutation breeding practices, raising and evaluation of segregating populations;
15. Use of mutagens to induce mutations and polyploidy
16. Visit to Biotechnology Lab & study of *in vitro* breeding techniques
17. **Final practical examination**

LEARNING OUTCOME

The students will be able do the breeding of fruit crops through various conventional and biotechnological methods besides mutation breeding.

SUGGESTED READING

1. Chadha KL and Shikhamany SD. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House, New Delhi.
2. Janick and Moore JN. 1996. Advances in Fruit Breeding, AVI Pub., USA.

3. Janick J and Moore JN. 1996. Fruit Breeding. Vols. I to III. John Wiley & Sons.
4. Kumar N. 2006. Breeding of Horticultural Crops - Principles and Practices. New India Publishing Agency, New Delhi.
5. Moore JN and Janick Jules. 1996. Methods in Fruit Breeding. Purdue University Press, South Campus Court D., USA.
6. Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK. And Mohanadas S. 2001. Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash, Kolkata.
7. Ray PK. (2002) Breeding of Tropical and Sub-tropical Fruits. Narosa Publishing House, New Delhi.
8. Simmonds N.W. 1976. Evolution of Crop Plants, Orient Longman, London.

SUGGESTED WEBSITE

1. https://www.hort.purdue.edu/newcrop/pdfs/fruit-breeding-brazil.pdf
2. https://www.frontiersin.org/articles/10.3389/fpls.2020.01234/full
3. https://www-pub.iaea.org/MTCD/Publications/PDF/te_1615_web.pdf

GPB 515 Breeding Ornamental Crops 2+1

WHY THIS COURSE?

Impart knowledge to student about breeding of ornamental crops through conventional and biotechnological interventions.

AIM OF THE COURSE

To educate about principles and practices adopted for breeding of ornamental crops.

THEORY

Unit I

History and improvement of ornamental plants; Centre of origin of ornamental crops; Objectives and techniques in ornamental plant breeding.

Unit II

Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops *viz.*, rose, jasmine, chrysanthemum, tuberose, gerbera, gladiolus, dahlia.

Unit III

Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops viz., lilium, gaillardia, petunia, bouganvillea, pansy, marigold, geranium, antirrhinum, china aster, orchids, carnation, hibiscus etc.

Unit IV

Development of promising cultivars of important ornamental and flower

crops; Role of Heterosis and its exploitation, production of F1 hybrids and utilization of male sterility.

Unit V

Production of open pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

PRACTICAL

Study of floral biology and pollination in important species and cultivars of ornamental crops-Techniques of inducing polyploidy and mutation-Production of pure and hybrid seed-Methods of breeding suited to seed propagated plants-Polyploidy and mutations to evolve new varieties-Breeding methods for biotic and abiotic stresses-Visit to research institutes involved in ornamental crop breeding.

LECTURE SCHEDULE

1. History of improvement of ornamental plants
2. Importance of ornamental crops and ornamental crops breeding
3. Centre of origin of ornamental crops
4. Objectives and techniques in ornamental plant breeding.
5. Mode of reproduction and pollination control in Ornamental crops
6. Issues in ornamental crops breeding
7. Special breeding approaches for Ornamental crops breeding
8. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Rose
9. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Jasmine
10. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Chrysanthemum
11. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Tuberose
12. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Gerbera
13. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Gladiolus
14. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Dahlia
15. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Lilium
16. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Gaillardia
17. **Mid semester examination**
18. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Petunia
19. Introduction, selection, hybridization, mutation and biotechnological techniques for

improvement of ornamental and flower crops – Bouganvillea
20. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Pansy
21. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Marigold
22. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Geranium
23. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Antirrhinum
24. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – China aster
25. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Orchids
26. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Antirrhinum
27. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Carnation
28. Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops – Hibiscus
29. Development of promising cultivars of important ornamental and flower crops
30. Role of Heterosis and its exploitation
31. Production of F1 hybrids and utilization of male sterility
32. Production of open pollinated seeds
33. Harvesting, processing and storage of seeds
34. Seed certification

PRACTICAL SCHEDULE

1. Study of floral biology and pollination in important species and cultivars of Rose
2. Study of floral biology and pollination in important species and cultivars of Jasmine
3. Study of floral biology and pollination in important species and cultivars of Chrysanthemum
4. Study of floral biology and pollination in important species and cultivars of Tuberose, Gerbera, Pansy
5. Study of floral biology and pollination in important species and cultivars of Gladiolus, Dahlia, Lilium
6. Study of floral biology and pollination in important species and cultivars of Petunia, marigold, geranium
7. Study of floral biology and pollination in important species and cultivars of orchids
8. Study of floral biology and pollination in important species and cultivars of cut flowers
9. Techniques of inducing polyploidy
10. Techniques of inducing mutation
11. Production of pure and hybrid seed

12. Methods of breeding suited to seed propagated plants
13. Polyploidy and mutations to evolve new varieties
14. Breeding methods for biotic stresses
15. Breeding methods for abiotic stresses
16. Visit to research institutes involved in ornamental crop breeding
17. **Final practical examination**

LEARNING OUTCOME

The students will be able to do the breeding of ornamental crops by conventional breeding and biotechnological methods and to know the genetics of major ornamental crops.

SUGGESTED READING

1. Alexander V.2002. Breeding for ornamentals: Classical and Molecular Approaches. Kluwer Academic Publishers, London.
2. Bhattacharjee SK and De LC. 2003. Advanced Commercial Floriculture Vol. 1. Aavishkar Publishers & Distributors, Jaipur.
3. Bose TK and Yadav LP. 2003. Commercial Flowers. Naya Prokash Publishers, Kolkata.
4. Chadha KL and Bhattacharjee SK. Advances in Horticulture Vol. 12, Malhotra Publishing House, New Delhi.
5. Mc Donald MB and Kwong FY. 2005. Flower Seeds Biology and Technology, CABI
6. Publishing, Oxfordshire, UK.
7. Watts L.1980. Flower and Vegetable Plant Breeding. Grower Books.

SUGGESTED WEBSITE

1. http://www.jhortscib.com/
2. http://journal.ashspublications.org/
3. http://www.actahort.org/

GPB 516 Breeding for Stress Resistance and Climate change 2+1

WHY THIS COURSE?

Enable the students understand the concept of breeding for stress tolerance and development of hybrids/ varieties for climate change.

AIM OF THE COURSE

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress tolerant varieties.

THEORY

Unit I

Concept and impact of climatic change; Importance of plant breeding with special reference to Biotic and abiotic stress resistance; Classification of biotic stresses–major pests and diseases of economically important crops.

Unit II

Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms ; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

Unit III

Types and genetic mechanisms of resistance to biotic stresses Horizontal and vertical resistance in crop plants; Quantitative resistance/adult plant resistance and slow rusting resistance; Classical and molecular breeding methods-Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data–Gene pyramiding methods and their implications. Classification of abiotic stresses-Stress inducing factors, moisture stress/drought and water logging & submergence; Acidity, salinity/alkalinity/sodicity; High/low temperature, wind, etc; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Unit IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low Water regimes and water logging & submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.

Unit V

Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

PRACTICAL

Understanding the climatological parameters and predisposal of biotic and abiotic stress factors-ways of combating them for diseases caused by fungi and bacteria - Symptoms and data recording; use of MAS procedures-Phenotypic screening techniques for sucking pests and chewing pests–Traits to be observed at plant and insect level-Phenotypic screening techniques for nematodes and borers; Ways of combating them.

Evaluating the available populations like RIL, NIL etc. for pest resistance-Use of standard MAS procedures. Breeding strategies-Weeds–ecological, environmental impacts on the crops-Breeding for herbicide resistance - Screening crops for drought and flood resistance; factors to be considered and breeding strategies Screening varieties of major crops for acidity and alkalinity-their effects and breeding strategies - Screening forage crops for resistance to sewage water and tannery effluents –Quality parameters evaluation.

LECTURE SCHEDULE

1. Concept and impact of climatic change in stress resistance breeding
2. Importance of plant breeding with special reference to biotic and abiotic stress resistance
3. Classification of biotic stresses–major pests and diseases of economically important crops
4. Concepts of resistance to insect and pathogen–inheritance of resistance
5. Host defense mechanism in responses to pathogen invasions-Biochemical and molecular mechanisms
6. Acquired and induced immunity and systemic acquired resistance(SAR)
7. Host-pathogen interaction, gene-for-genehypothesis–Molecular evidence
8. Concept of signal transduction and other host-defense mechanisms against viruses and bacteria
9. Types and genetic mechanisms of resistance to biotic stresses–Horizontal and vertical resistance in crop plants
10. Quantitative resistance/adult plant resistance and slow rusting resistance
11. Host plant resistance to insects, mechanisms–antixenosis, antibiosis and tolerance
12. Classical breeding methods for pest and disease resistance
13. Molecular breeding method for pest and disease resistance
14. Behavioural, physiological and insect gain studies
15. Phenotypic screening methods for major pests and diseases
16. Gene pyramiding methods and their implications
17. **Mid semester examination**
18. Classification of abiotic stresses
19. Stress inducing factors: moisture stress/drought and water logging & submergence, Acidity, salinity/alkalinity/sodicity, High/low temperature, wind, etc
20. Stress due to soil factors and mineral toxicity
21. Physiological and Phenological responses to abiotic stresses
22. Genetics of abiotic stress resistance
23. Genes and genomics in breeding cultivars suitable for various abiotic stresses
24. MAS to develop resistant varieties in rice – case studies
25. MAS to develop resistant varieties in sorghum - case studies
26. MAS to develop resistant varieties in wheat - case studies
27. MAS to develop resistant varieties in cotton - case studies
28. Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.

29. Use of crop wild relatives as a source of resistance to pests and diseases
30. Use of crop wild relatives as a source of resistance to abiotic stresses
31. Transgenics for biotic resistance
32. Transgenics for abiotic resistance
33. Transgenics for biotic and abiotic resistance – case studies
34. Use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management

PRACTICAL SCHEDULE

1. Understanding the climatological parameters and forecasting of diseases and pests
2. Phenotypic screening for bacterial and fungal diseases–data recording
3. Phenotypic screening for viral diseases-symptoms and data recording
4. Phenotypic screening techniques for sucking pests and chewing pests
5. Phenotypics creening techniques for nematodes and borers
6. Development of NILs–case study
7. Evaluation of Mapping population RIL, NIL etc for diseases
8. Evaluation of Mapping population RIL, NIL etc for pests
9. MAS-procedure
10. Use of standard MAS procedures–MAB–case study
11. Breeding for herbicide resistance
12. Screening crops for drought and flood resistance
13. Screening crops for salinity, alkalinity and sodicity
14. Screening crops for water logging & submergence
15. Screening forage crops for resistance to sewage water and tannery effluents
16. Quality parameters evaluation of forage crops grown under sewage water
17. **Final practical examination**

LEARNING OUTCOME

The student will be able to well verse with the stress and its causes. This will enable the students for the development of RIL, NIL etc. for pest resistance and Use of standard MAS procedures.

SUGGESTED READING

1. Blum A.1988. Plant Breeding for Stress Environments. CRCPress.
2. Christiansen MN& Lewis CF.1982.Breeding Plants for Less Favourable Environments. Wiley International.
3. Fritz RS & Simms EL.(Eds.).1992.Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics. The University of Chicago Press.
4. Li PH & Sakai A.1987.Plant Cold Hardiness. Liss, NewYork Springer.
5. LuginpillP.1969. Developing Resistant Plants-The Ideal Method of Controlling Insects. USDA, ARS, Washington DC.
6. Maxwell FG & Jennings PR.(Eds.).1980. Breeding Plants Resistant to Insects. John Wiley& Sons. Wiley-Blackwell.
7. Roberto F.2018.Plant Breeding for Biotic & Abiotic Stress Tolerance. Springer.

8. RusselGE.1978. Plant Breeding for Pest and Disease Resistance. Butter worths.
9. Sakai A& Larcher W.1987.Frost Survival in Plants. Springer-Verlag.
10. Singh BD.2006. Plant Breeding. Kalyani Publ.
11. Turener NC & Kramer PJ.1980.Adaptation of Plants to Water and High Temperature Stress. John Wiley&Sons.
12. Vander Plank JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

SUGGESTED WEBSITE

1. https://www.cabi.org/cabebooks/ebook/20113319826
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2610105/
3. https://www.researchgate.net/publication/236885656
4. https://www.frontiersin.org/articles/10.3389/fpls.2015.00563/full

GPB 517 Germplasm Characterization and Evaluation 1+1

WHY THIS COURSE?

Enable students to learn about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses.

AIM OF THE COURSE

To gain knowledge on germplasm characterisation, evaluation and documentation of information. Recording of morphological and agronomic traits, including quality, resilience to biotic and abiotic stresses. Exposure to development of web based tools for systematic description for efficient use of germplasm.

THEORY

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits.

Unit II

Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit III

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation o farmer landraces.

Unit IV

Evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Unit V

High throughput phenotyping systems- imaging & image processing concepts for automated germplasm characterization (phenotyping) – evaluation for nutritional traits, resistance traits - Biochemical and molecular markers for characterization.

PRACTICAL

Field layout and experimental designs; recording field data on germplasm evaluation in different agri-horticultural crops, post-harvest handling; evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing; documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

LECTURE SCHEDULE

1. Understanding genetic diversity in crop plants
2. Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures
3. Evaluation of germplasm for specific traits
4. Measuring diversity using agro-morphological data
5. Statistical procedures to measure population genetic variation, markers and their use inPGR
6. Evaluation of biotic and abiotic stresses
7. Principles and methods for formulating core and mini core collections and their validation
8. **Mid semester examination**
9. Web based tools for management of data
10. Principles and practices of germplasm regeneration and maintenance
11. Breeding systems and mode of reproduction
12. Maintaining sufficiently large populations for effective conservation of farmer landraces
13. Evaluation and maintenance of wild relatives of crop plants
14. Genetic enhancement, Use of CWRs genetic resources for crop improvement
15. High throughput phenotyping systems- imaging & image processing concepts for automated germplasm characterization (phenotyping)
16. Evaluation for nutritional traits, resistance traits
17. Biochemical and molecular markers for characterization

PRACTICAL SCHEDULE

1. Field layout and experimental designs
2. Recording field data on germplasm evaluation in different agri-horticultural crops: Cereals and millets
3. Recording field data on germplasm evaluation in different agri-horticultural crops: Pulses
4. Recording field data on germplasm evaluation in different agri-horticultural crops:

Oilseed crops

5. Recording field data on germplasm evaluation in different agri-horticultural crops: Cotton and sugarcane
6. Recording field data on germplasm evaluation in different agri-horticultural crops: Vegetable crops
7. Recording field data on germplasm evaluation in different agri-horticultural crops: Fruit crops
8. Post-harvest handling
9. Evaluating quality traits
10. Biochemical and phyto-chemical evaluation of crop germplasm
11. Data processing
12. Analysis of diversity
13. Data analysis, viability equations
14. Sampling strategies
15. Data documentation and cataloguing
16. Biochemical analyses of samples
17. **Final practical examination**

LEARNING OUTCOME

Students will know about science of managing genetic resources including principles involved in maintaining genetic integrity during regeneration, germplasm characterization and evaluation.

SUGGESTED READING

1. Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. Plant Genetic Resources Evaluation: Principles and Procedures, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi.
2. Brown, AHD, Clegg, MT, Kahler, AL, Weir, BS (eds.) 1990. Plant Population Genetics, Breeding, and Genetic Resources, Sinauer Associates, USA.
3. Frankel, R and Galun, E 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics, Springer-Verlag, Berlin, Heidelberg.
4. Hayward, MD, Bosemak, NO and Romagosa, I. 1993. Plant Breeding: Principles & Practices, Chapman & Hall.
5. Holden, JHN and Williams, JT 1984. Crop genetic resources: conservation and evaluation, IBPGR.
5. Stoskopf, NC 1993. Plant Breeding: Theory & Practice, Westview Press.
6. Puzone, L and Th. Hazekamp 1996. Characterization and Documentation of Genetic Resources Utilizing Multimedia Database. NBPGR, New Delhi.
7. Rana, RS, Sapra, RL, Agrawal, RC and Gambhir, R 1991. Plant Genetic Resources, Documentation and Information Management. NBPGR, New Delhi.
8. Sundeep Kumar, et al 2016.Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch

diseases. PloS One Vol 11, pages 0167702.

SUGGESTED WEBSITE

1. https://cropgenebank.sgrp.cgiar.org/index.php/procedures-mainmenu42/characterization-mainmenu-205
2. https://www.frontiersin.org/articles/10.3389/fpls.2014.00068/full
3. https://www.iaea.org/sites/default/files/21/06/nafa-pbg-manual-molecular-characterizationmutant- germplasm-manual-2015.pdf

GPB 518 Genetic Enhancement for PGR Utilization 1+1

WHY THIS COURSE?

Inculcate theoretical and practical know how to understand and use classical and advanced plant breeding methods for planning and execution of pre-breeding programmes so that the PGR is put into effective use for food and agriculture.

AIM OF THE COURSE

To teach theoretical and practical know how on CWRs reproductive behavior, acclimatization and adaptation for utilization in pre-breeding programmes using advanced tools.

THEORY

Unit I

Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi exotics, creating and managing variation, basic concepts to set up a successful prebreeding programme.

Unit II

Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm.

Unit III

Identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

Unit IV

Parental selection for pre breeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical approaches for gene transfer such as alien addition and substitution, segregating

populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods.

Unit V

Pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre & post-zygotic barriers.

PRACTICAL

Characterization of CWRs by visiting the fields - screening methods for special traits- biotic and abiotic resistance - Screening for nutritional traits - Crossability studies in CWRs of cereals, legumes, oilseeds, vegetables. Assessment of pre and post-zygotic barriers in wide hybridization crosses - Pollen storage studies - special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, etc.

LECTURE SCHEDULE

1. Concepts of gene pools Introduction, potential of pre-breeding
2. Role of crop wild relatives, semi exotics, creating and managing variation
3. Basic concepts to set up a successful pre breeding programme
4. Understanding crop adaptation, handling and maintenance of CWRs
5. Synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments
6. Role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable traits in natural populations
7. Screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits
8. **Mid semester examination**
9. Genetic analysis to understand the inheritance of novel traits
10. Parental selection for pre-breeding, search for superior genotypes
11. Breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization
12. Incongruity and its management, modern tools for incongruity management
13. Cytogenetical approaches for gene transfer such as alien addition and substitution
14. Segregating populations and their management in wide crosses
15. Purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods
16. Pollen physiology and storage, pollen storage methods to facilitate wide hybridization
17. Pre & post-zygotic barriers

PRACTICAL SCHEDULE

1. Characterization of CWRs by visiting the fields- rice
2. Characterization of CWRs by visiting the fields- pulses
3. Characterization of CWRs by visiting the fields- millets & oilseeds
4. Characterization of CWRs by visiting the fields- cotton

5. Characterization of CWRs by visiting the fields- Forage crops
6. Screening methods for special traits-biotic resistance
7. Screening methods for special traits-abiotic resistance
8. Screening for nutritional traits
9. Crossability studies in CWRs of cereals,
10. Crossability studies in CWRs of legumes
11. Crossability studies in CWRs of oilseeds
12. Crossability studies in CWRs of vegetables
13. Assessment of pre-zygotic barriers in wide hybridization crosses
14. Assessment of post-zygotic barriers in wide hybridization crosses
15. Pollen storage studies
16. Special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, etc.
17. **Final practical examination**

LEARNING OUTCOME

Students would be conversant with handling of unadapted germplasm, screening methods for special traits-biotic and abiotic resistance, nutritional traits, characterization of CWR, breeding, etc.

SUGGESTED READING

1. Sharma S, Upadhyaya HD, Varshney RK, et al. 2013.Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. Front. Plant Sci.4:309.
2. Bisht et al. 2004. Broadening the genetic base of sesame (Sesamum indicum L.) through genetic enhancement. Plant Genetic Resources 2 (3) : 143-151.
3. Duvick, DN. 1990. Genetic enhancement and plant breeding. p. 90-96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.
4. Ramanatha Rao, V, Brown AHD, Jackson M. 2001. Managing Plant Genetic Diversity. CABI Publication.
5. Goodman, RM. 2004. Encyclopedia of plant and crop science. Marcel Dekker Inc., Switzerland.
6. Kimber, G and Feldman, M. 1987. Wild Wheat: An introduction. Special report 353, College of Agriculture, University of Missouri-Columbia.

SUGGESTED WEBSITE

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7907825/
2. https://www.pnas.org/content/96/11/5937
3. https://academic.oup.com/bfg/article/17/3/198/4982565

MINOR COURSES

PLP 501 **Principles of Plant Physiology I: Plant Water Relations and Mineral Nutrition** **2+1**

WHY THIS COURSE?

Agricultural productivity depends on two major inputs like water and nutrients. In this regard, this course being a fundamental course will acquaint the students with the basic concepts of plant water relations and mineral nutrition. Also course provides a basic knowledge on water and nutrient acquisition and their transport throughout the phenological stages. Further, it also provides hands on experience in assessing the plant and soil water status besides nutrient acquisition by plants.

AIM OF THE COURSE

- To impart knowledge on water relations and mineral nutrition and how plants acquire water and transport it under different soil water regimes to maximize use efficiency.
- To impart knowledge of how plants minimize water loss under stress conditions and also how plants make use of nutrients in a best possible way.

THEORY

Unit I: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water-Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion Soil physical properties and water availability in different soils; Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit II: Water Absorption, Translocation and Transpiration

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins-water channel proteins. Mycorrhizal association and its relevance in water mining. Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance-Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure – Anti-transpirants and their relevance in agriculture.

Unit III: Water Productivity and Water use efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE. Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Unit IV: Nutrient Elements and Their Importance – Concept of Foliar nutrition

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants-Deficiency and toxicity symptoms in plants-Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

Unit V: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels-Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition.

PRACTICAL

Standard solutions and preparation of different forms of solutions-Studies on the basic properties of water-Measurement of plant water status - Relative water content-Determination of water potential -Chardakov's test-Determination of water potential using pressure bomb apparatus-Determination of water potential using Osmometer-Determination of soil moisture content and Use of soil moisture probes/ sensors-Measurement of transpiration rate in plants - Measurement of CCATD and its relevance Demonstration and use of anti-transpirants- - Stimulating the deficiency symptoms in solution culture by creating nutrient deficiency (-N; -P; -K; -Zn; -Fe)- Deficiency and toxicity symptoms of macro-nutrients-Deficiency and toxicity symptoms of macro-nutrients-Rapid tissue Test for macronutrients- Micro nutrient estimation using AAS- Demonstration of nutrient application techniques-Field visits for foliar diagnosis

LECTURE SCHEDULE

1. Water and its importance-Molecular structure of water- Properties and functions of water
2. Concept of water potential - Plant cell and soil water potential and their components
3. Methods to determine cell and soil water potential-Concept of osmosis and diffusion
4. Soil physical properties and water availability in different soils - Water holding capacity and approaches to improve WHC- Concept of FC and PWP - Water holding polymers and their relevance
5. Root structure and functions- Root architecture and relevance in water mining
6. Mechanisms of water absorption – Pathways of water movement – Apoplast and Symplast.

7. Translocation of water – ascent of sap – Theories explaining water absorption and translocation- Aquaporins
8. Mycorrhizal association and its relevance in water mining
9. Evaporation and transpiration- factors regulating transpiration- Measurement of transpiration
10. Approaches to minimize evaporation and transpiration- Concept of CCATD and its relevance
11. Energy balance: Solar energy input and output at crop canopy level
12. Stomata- its structure, functions and distribution- Molecular mechanisms of stomatal opening and closing-Concept of guard cell turgidity
13. Mechanism and role of K and other osmolytes in stomatal opening- role of ABA in stomatal closure
14. Guard cells response to environmental signals- Signaling cascade associated with stomatal opening and closure - Antitranspirants and their relevance in agriculture.
15. WUE and its relevance in water productivity - intrinsic& whole plant WUE
16. Approaches to measure WUE- gravimetry, instantaneous & carbon isotope discrimination.
17. **Mid semester examination**
18. Stomatal and mesophyll regulation on WUE
19. Transpiration efficiency –Advances and challenges -Passioura's yield model emphasizing WUE.
20. Physiology of water stress in plants- Effect of moisture stress at molecular, cellular, organ and plant level
21. Drought indices and drought tolerance strategies - Drought tolerance traits
22. Role of mineral nutrients in plant's metabolism- critical levels of nutrients – interaction between nutrients
23. Essential elements –classification-factors influencing the nutrients availability
24. Beneficial elements -Types-Physiological role.
25. Nutrient deficiency and toxicity in plants.
26. Foliar nutrition-significance-Foliar nutrient droplets size for effective entry-role of wetting agents in entry of nutrients.
27. Soiless culture-hydroponics, aeroponics.
28. Nutrient availability – Ion competition, antagonism and synergism. Mechanism of mineral uptake and translocation - Ion uptake and transport-Theories related to ion uptake
29. Ion transporters- genes encoding for ion transporters - localization of transporters -
30. Xylem and phloem mobility of nutrients
31. Nutrient transport to grains at maturity-Mechanism
32. Strategies to acquire and transport minerals under deficient levels
33. Role of mycorrhiza in nutrient uptake and root exudates-mineral solubilization
34. PGPRs in plant nutrient acquisition-Nutrient Use Efficiency Enhancement

PRACTICAL SCHEDULE

1. Standard solutions and preparation of different forms of solutions
2. Studies on the basic properties of water-surface tension of water and other solvents
3. Measurement of plant water status - Relative water content
4. Determination of water potential – Plasmolysis and Chardakov's test
5. Determination of water potential using pressure bomb apparatus
6. Determination of soil moisture using probes/ sensors
7. Measurement of transpiration rate in plants
8. Demonstration and use of anti-transpirants
9. Determination of WUE
10. Measurement of CCATD
11. Deficiency and toxicity symptoms of macro and micronutrients
12. Rapid tissue Test for macro and micronutrients
13. Assessing chlorophyll/nitrogen status using SPAD meter
14. Effect of drought stress at cellular level by measuring peroxidase activity
15. Measurement of drought indices
16. Demonstration of nutrient application techniques
17. **Final Practical examination**

LEARNING OUTCOME

By the end of this course, the student will be able to understand the fundamental concepts of plant physiological processes associated with water relation and mineral nutrition-the physiological mechanisms of water relation and mineral nutrition-recognize and describe how plants respond to mineral deficiency and toxicity.

SUGGESTED READING

1. Taiz T, Zeiger E and Max Miller IM, 2018, Fundamentals of Plant Physiology
2. Taiz L and Zeiger E. 2015. Plant Physiology and development.6th Ed Salisbury FB and Ross C. 1992 (4th Ed.) Plant Physiology
3. Emanuel Epstein and Arnold J. Bloom.2004, Mineral nutrition of plants: principles and perspectives.2nd Ed.
4. Hopkins WG and Huner NPA. 2004. Introduction to Plant Physiology
5. Kirkham, M. B., Principles of soil and plant water relations
6. Epstein E. 2007. *Mineral Nutrition of Plants*. John Wiley & Sons
7. Kramer, P. J., Water relations of plants
8. Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press
9. Hopkins WG, 2008, Introduction to Plant Physiology
10. Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition* CRC

SUGGESTED WEBSITE

1. http://www.plantphys.org
2. http://4e.plantphys.net /

PLP 502 Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation 2+1

WHY THIS COURSE?

Mechanisms associated with growth and development determine crop performance under any given condition. Metabolic and growth processes are quite sensitive to environmental factors and hence comprehensive understanding of the physiological basis of growth and development would be essential.

AIM OF THE COURSE

Mechanisms associated with growth and development determine crop performance under any given condition. Metabolic and growth processes are quite sensitive to environmental factors and hence comprehensive understanding of the physiological basis of growth and development would be essential.

Unit I: Carbon Metabolism – Photochemical Processes

Chloroplast ultrastructure - lamellar system - Excitation, electron and proton transfers and their relevance in energy conservation - Concepts of pigment systems and generation of powerful reductant and oxidant. Water oxidation & Light reaction - Water-water cycle and other aspects of electron transfer

Unit II: Carbon Metabolism –Biochemical Processes

CO_2 diffusion mechanisms and diffusive conductance, concept of C_i determining photosynthesis - RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycle and metabolite fluxes. Photorespiration: the advantages and inefficiencies of photosynthesis - Concepts of CO_2 concentrating mechanisms and spatial and temporal differences in carboxylation - Ecological aspects of C_4 and CAM photosynthesis - Product synthesis: Starch and Sucrose biosynthesis.

Unit III: Carbon Metabolism: Respiration, Product Synthesis and Translocation

Mitochondrial organization and functions - Aspects of Glycolysis, TCA cycle and mitochondrial ETC - Relevance of growth and maintenance respiration. Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC. Phloem loading and sugar transporting, concepts of bi-directional transport of sugars and other metabolites - Source-Sink relationship and modulation of photosynthesis - Concepts and definitions of Growth and Differentiation - Growth and yield parameters: NAR, CGR, HI and concepts of LAI, and LAD.

Unit IV: Nitrogen Assimilation & Protein Synthesis, Lipid Metabolism and Secondary Metabolites

Nitrogen fixation - Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis - Inter-dependence of carbon assimilation and nitrogen metabolisms - Storage, protective and structural lipids - Biosynthesis of fatty-acids, diacyl and triacyl

glycerol, fatty acids of storage lipids - Secondary metabolites and their significance in plant defense mechanisms.

Unit V: Hormonal Regulation of Plant Growth and Development and Synthetic Growth Promoters - Morphogenesis and Reproductive Phase

Growth promoting and retarding hormones: biosynthesis, transport, and conjugation – Mode of action and application. New generation hormones/synthetic hormones: Salicylic acid, strigolactones and brassinosteroids - Mode of action and application. Photoperiodism: Phytochromes, their structure and function - Circadian rhythms, - Blue light receptors: Cryptochrome and morphogenesis - Vernalization and its relevance in germination.

PRACTICAL

Radiant energy measurements, Separation and quantification of chlorophylls, Separation and quantification of carotenoids, O_2 evolution during photosynthesis, Anatomical identification of C_3 and C_4 plants, Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Measurement of respiration rates, Estimation of reducing sugars, starch, Estimation of NO_3, free amino acids in the xylem exudates, quantification of soluble proteins, Bioassays for different growth hormones - Auxins, Gibberellins, Cytokinins, ABA and ethylene, Demonstration of photoperiodic response of plants in terms of flowering.

LECTURE SCHEDULE

1. Chloroplast ultrastructure with special mention of lamellar system,
2. Excitation, electron and proton transfers and their relevance in energy conservation
3. Concepts of pigment systems and generation of powerful reductant and oxidant
4. Water oxidation, and other aspects of electron transfer
5. Light reaction – cyclic and noncyclic photophosphorylation
6. Water-water cycle
7. CO2 diffusion mechanisms and diffusive conductance, concept of Ci determining photosynthesis
8. RuBisCO enzyme kinetics and Calvin cycle mechanisms
9. Regulation of Calvin cycle and metabolite fluxes
10. Photorespiration: the advantages and inefficiencies of photosynthesis because of photorespiration
11. Concepts of CO2 concentrating mechanisms and spatial and temporal differences in carboxylation.
12. Ecological aspects of C4 and CAM photosynthesis
13. Product synthesis: Starch and Sucrose biosynthesis
14. Mitochondrial organization and functions, and glycolysis & TCA cycle
15. Mitochondrial ETC and relevance of growth and maintenance respiration
16. Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC
17. **Mid-semester examination**
18. Source-Sink relationship and modulation of photosynthesis

19. Phloem loading: concepts of bi-directional transport of sugars and other metabolites
20. Concepts and definitions of Growth and Differentiation
21. Growth and yield parameters: NAR, CGR, RGR, HI and concepts of LAI, LAD, SLW, SLA
22. Recent developments in Nitrogen fixation
23. Nitrate reduction and assimilation: GS-GOGAT process for amino acid synthesis
24. Inter-dependence of carbon assimilation and nitrogen metabolisms
25. Storage, protective and structural lipids
26. Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids
27. Secondary metabolites and their significance in plant defense mechanisms
28. Growth promoting hormones – auxin, GA, - Biosynthesis, transport, conjugation, Mode of action and their application
29. CKs, ABA & Ethylene - Biosynthesis, transport, conjugation, Mode of action and their application.
30. Brassinosteroids, Salicylic acid and Strigolactones: Biosynthesis, Mode of action and their application
31. Synthetic plant growth regulators – growth promoters and retardants- Commercial applications to maximize growth and productivity
32. Photoperiodism: Phytochromes - structure and function.
33. Circadian rhythms: Blue light receptors: Cryptochrome and morphogenesis.
34. Vernalization and its relevance in germination

PRACTICAL SCHEDULE

1. Radiant energy measurements
2. Separation and quantification of chlorophylls
3. Separation and quantification of carotenoids
4. Anatomical identification of C_3 and C_4 plants
5. Estimation of photochemical efficiency – PS II
6. Measurement of gas exchange parameters: conductance and photosynthetic rate
7. Growth analysis
8. Estimation of reducing sugars/starch
9. Quantification of soluble proteins
10. Estimation of free amino acids
11. Bioassays for Auxins
12. Bioassays for Gibberellins
13. Bioassays for Cytokinins
14. Bioassays for ABA
15. Bioassays for Ethylene
16. Demonstration of photoperiodic response of plants in terms of flowering
17. **Final practical examination**

LEARNING OUTCOME

By the end of this course, the student will be able to understand the

fundamental metabolic processes in plant. Understanding the physiological mechanisms and metabolic events associated with regulation of plant growth.

SUGGESTED READING

1. Plant Physiology, Taiz, Lincoln, Zeiger, Eduardo Origan, Sinauer Associates, Inc., Springer.
2. Plant Physiology - Frank Boyer Salisbury and Cleon Ross.
3. Introduction to Plant Physiology - William G. Hopkins

SUGGESTED WEBSITE

1. Kirchhoff, H., (2019). Chloroplast ultrastructure in plants, New Phytologist https://doi.org/10.1111/nph.15730.
2. Jafari, T., Moharreri, E., Amin, A., Miao, R., Song, W., and Suib, S. (2016). Photocatalytic water splitting—the untamed dream: a review of recent advances. Molecules, 21(7), 900.
3. Jensen E, Cle´ment R, Maberly SC, Gontero B. 2017 Regulation of the Calvin – Benson–Bassham cycle in the enigmatic diatoms: biochemical and evolutionary variations on an original theme. Phil. 4. Trans. R. Soc. B 372: 20160401
4. http://dx.doi.org/10.1098/rstb.2016.0401
5. Raven, J. A., and Beardall, J. (2015). The ins and outs of CO2.Journal of experimental botany, 67(1), 1-13.
6. Rae, B. D., Long, B. M., Förster, B., Nguyen, N. D., Velanis, C. N., Atkinson, N. .and McCormick, A. J. (2017). Progress and challenges of engineering a biophysical CO2-concentrating mechanism into higher plants. Journal of Experimental Botany, 68(14), 3717-3737.
7. Hagemann, M., Weber, A. P., and Eisenhut, M. (2016). Photorespiration: origins and metabolic integration in interacting compartments. Journal of experimental botany, 67(10), 2915.
8. Kühlbrandt, W. (2015). Structure and function of mitochondrial membrane protein complexes.BMC biology, 13(1), 89.
9. Liesche, J., and Patrick, J. (2017). An update on phloem transport: a simple bulk flow under complex regulation. F1000Research, 6.
10. Jensen, K. H., Berg-Sørensen, K., Bruus, H., Holbrook, N. M., Liesche, J., Schulz, A., and Bohr, T. (2016). Sap flow and sugar transport in plants. Reviews of modern physics, 88(3), 035007.
11. ulius, B. T., Leach, K. A., Tran, T. M., Mertz, R. A., and Braun, D. M. (2017). Sugar transporters in plants: new insights and discoveries. Plant and Cell Physiology, 58(9), 1442-1460.
12. Rao, D. L. N. (2014). Recent advances in biological nitrogen fixation in agricultural systems. In Proc Indian Natl Sci Acad (Vol. 80, No. 2, pp. 359-378).
13. Hoffman, B. M., Lukoyanov, D., Yang, Z. Y., Dean, D. R., and Seefeldt, L. C. (2014). Mechanism of nitrogen fixation by nitrogenase: the next stage. Chemical reviews, 114(8), 4041-4062

14. Mus, F., Crook, M. B., Garcia, K., Costas, A. G., Geddes, B. A., Kouri, E. D.andUdvardi, M. K. (2016). Symbiotic nitrogen fixation and the challenges to its extension to nonlegumes. Appl. Environ. Microbiol.,82(13), 3698-3710.
15. Pagare, S., Bhatia, M., Tripathi, N., Pagare, S., and Bansal, Y. K. (2015). Secondary metabolites of plants and their role: Overview. Curr Trends Biotechnol Pharm, 9(3), 293-304.
16. Jain C, Khatana S and Vijayvergia R: Bioactivity of secondary metabolites of various plants: a review. Int J Pharm Sci and Res 2019; 10(2): 494-04. doi: 10.13040/IJPSR.0975-8232.10(2).494-04.
17. Li, C., Li, J., Chong, K., Harter, K., Lee, Y., Leung, J.,and Schroeder, J. (2016). Toward a molecular understanding of plant hormone actions.Molecular plant, 9(1), 1-3.
18. Eckardt, N. A. (2015). The plant cell reviews dynamic aspects of plant hormone signaling and crosstalk.
19. Jiang, K., andAsami, T. (2018). Chemical regulators of plant hormones and their applications in basic research and agriculture.Bioscience, biotechnology, and biochemistry, 82(8), 1265-1300.
20. Zwanenburg, B., Pospíšil, T., and Zeljković, S. Ć. (2016). Strigolactones: new plant hormones in action. Planta, 243(6), 1311-1326.
21. Kumar, R., Khurana, A., and Sharma, A. K. (2014). Role of plant hormones and their interplay in development and ripening of fleshy fruits.Journal of experimental botany, 65(16), 4561-4575.
22. Gururani, M., Mohanta, T., and Bae, H. (2015). Current understanding of the interplay between phytohormones and photosynthesis under environmental stress.International journal of molecular sciences, 16(8), 19055-19085.
23. Song, Y. H., Shim, J. S., Kinmonth-Schultz, H. A., and Imaizumi, T. (2015). Photoperiodic flowering: time measurement mechanisms in leaves. Annual review of plant biology, 66, 441-464.
24. Sanchez, S. E., and Kay, S. A. (2016). The plant circadian clock: from a simple timekeeper to a complex developmental manager. Cold Spring Harbor perspectives in biology, 8(12), a027748.

PLP 504 Physiological and Molecular Responses of Plants to Abiotic Stresses 2+1

WHY THIS COURSE?

In recent years, our understanding of the physio-morphological, biochemical and molecular adaptation of plants to resource limited/stressful environment is phenomenal. This course will outline different abiotic stresses, their impacts on agricultural productivity, stress tolerance mechanisms, stress mitigation strategies, crop improvement approaches and traits for stress tolerance.

AIM OF THE COURSE

Students will gain insights into latest developments in stress physiology, stress tolerance mechanisms and approaches for crop improvement under stressful environment.

Unit I: Introduction to Abiotic stress and drought Stress responses

Introduction to abiotic stress – abiotic stresses major constraints to realize potential yields of crop plants, yield losses. Drought prone areas in India - frequency of occurrence of drought, rainfed-kharif, rabi. Areas affected by salinity, heavy metals, water logging, high temperature due to global warming. Drought-characteristic features -Water potential in the soil-plant-air continuum. Physiological and biochemical process affected by drought.

Unit II: Stress perception, Cellular and molecular responses of plants to drought stress.

Drought induced Oxidative stress - Generation of Reactive Oxygen Species and other cytotoxic compounds under water stress. Effects of ROS and other cytotoxic compounds on cellular processes. Effect on total carbon gain – decrease in photosynthetic area and function, protein turn over and lipid characters, phenology – reproductive aspects, critical stages. Molecular responses to drought stress: Stress perception and signal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with drought adaptive mechanisms

Unit III: Plant adaptive mechanism to drought and Approaches to Improve Drought stress tolerance

Escape and desiccation avoidance mechanism - concept of stress escape – exploiting genetic variability in phenology . Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters. Moisture conservation – regulation of transpiration – traits reducing heat load, stomatal factors, guard cell metabolism, moisture conservation by waxes. Water use efficiency (WUE) and concept of water productivity – regulation of transpiration efficiency – stomatal conductance, mesopyll efficiency, relevance of WUE and Passioura's yield model. Desiccation tolerance – osmolytes, ROS, RCC, membrane stability-concept of acquired tolerance. Development of genetic resources-donor genotypes for specific traits –Genomic resources - genes- QTL's regulating adaptive mechanisms – Conventional- transgenic and molecular breeding approaches to improve relevant adaptive traits - concept of trait introgression.

Unit IV: Salt Stress, Heavy metal stress and water logging

Soil salinity - Effect of salt stress - ionic and osmotic effects - species variation in salt tolerance – glycophytes and halophytes. Salt tolerance mechanisms–exclusion-extrusion and compartmentalization. Signaling during salt stress–SOS pathway. Approaches to improve salt tolerance.Heavy metal toxicity in plants - Al, Cd-tolerance mechanisms and approaches to improve metal toxicity. Plant responses to water logging, role of hormones – ethylene, mechanism of tolerance and approaches to improve.

Unit V: Temperature Stress and light stress

High and low temperatures – effect on plants – adaptive mechanisms, evaporation cooling – concept of cellular tolerance– protein stability-chaperones-HSPs-HSFs and membranes- Approaches to improve. High light and high ionizing radiation –photo-oxidation and photo-inhibition -mechanisms of tolerance. Plant adaptation to low light- concept of shade avoidance response (SAR).

PRACTICAL

Measurement of soil and plant water status – Measurement of gas exchange and fluorescence measurements – Water use efficiency – Determination of stress indices - Quantification root characters – Determination of stomatal parameters and canopy temperature – Determination of Epicuticular wax – Determination of Salinity Tolerance Index – Temperature induction response – Sullivans heat tolerance test –proline under stress – Quantification of ROS under stress – Estimation of antioxidant enzymes – Estimation of ABA- Estimation of Osmotic potential and osmotic adjustment – Determination of Sodium and Potassium ratio.

LECTURE SCHEDULE

1. Stress – classification of biotic and abiotic stress
2. Abiotic stresses as major constraints to realise potential yields of crop plant, yield losses.
3. Drought prone areas in India – frequency of occurrence of drought, rainfed-kharif, rabi
4. Areas affected by salinity, heavy metals, water logging, high temperature due to global warming
5. Drought-characteristic features, Water potential in the soil-Plant air continuum
6. Physiological and biochemical processes affected by drought
7. Drought induced Oxidative stress - Generation of Reactive Oxygen Species and other cytotoxic compounds under water stress
8. Effects of ROS and other cytotoxic compounds on cellular processes
9. Effect on total carbon gain – decrease in photosynthetic area and function, protein turn over and lipid characters, phenology – reproductive aspects, critical stages
10. Molecular responses to drought stress: Stress perception and signal transduction in plants involved in drought stress
11. Expression of regulatory genes, stress specific kinases, stress specific transcription factors associated with drought adaptive
12. Expression of functional genes associated with drought adaptive mechanisms
13. Concept of stress escape-exploiting genetic variability in phenology
14. Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters. Moisture conservation – regulation of transpiration – traits reducing heat load, stomatal factors, guard cell metabolism, moisture conservation by waxes.
15. Water use efficiency (WUE) and concept of water productivity – regulation of transpiration efficiency, mesophyll efficiency, relevance of WUE and Passioura's yield model
16. Desiccation tolerance - Concept of acquired tolerance

17. Mid-semester examination

18. Decreased turgor mediated upregulation of cellular tolerance mechanisms – osmolytes, managing cytotoxic compounds, ROS, RCC, scavenging- enzymatic and nonenzymatic, protein turnover, stability, chaperons, membrane stability, photoprotection of chlorophylls
19. Development of genetic resources – donor genotypes for specific traits
20. Genomic resources – genes, QTL's regulating adaptive mechanisms
21. Conventional and transgenic approaches to improve relevant drought adaptive traits
22. Molecular breeding approaches to improve drought adaptive traits and concept of trait introgression
23. Soil salinity, Effect of salt stress, ionic and osmotic effects; Species variation in salt tolerance; glycophytes and halophytes
24. Salt tolerance mechanisms - exclusion, extrusion and compartmentalization
25. Signaling during salt stress – SOS pathway,
26. Approaches to improve salt tolerance.
27. Heavy metal toxicity (Al and Cd) in plants, tolerance mechanisms and approaches to improve.
28. Plant responses to water logging, role of hormones – ethylene, mechanism of tolerance and approaches to improve
29. Physiological effects of high and low temperature stress on plants
30. Crucial role of membrane lipids in heat stress tolerance
31. Heat adaptive mechanisms: evaporation cooling, concept of cellular tolerance and protein stability
32. Role of chaperones, HSPs & HSFs
33. Highlight and high ionizing gradiation-photo-oxidation and photo -inhibition
34. Mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response

PRACTICAL SCHEDULE

1. Measurement of soil and plant water status.
2. Gas exchange and fluorescence measurements under drought.
3. Determination of water use efficiency.
4. Determination of stress indices.
5. Measurement of root traits.
6. Determination of stomatal parameters and canopy temperature under drought.
7. Determination of epicuticular wax.
8. Screening High Temperature Stress Tolerance by Temperature induction response.
9. Sullivan's heat tolerance test.
10. Estimation of lipid peroxidation (MDA content)
11. Quantification of proline.
12. Quantification of ROS.
13. Estimation of antioxidant enzymes.
14. Estimation of ABA content in plant tissues.

15. Estimation of Osmotic potential and osmotic adjustment
16. Determination of sodium and potassium ratio in plant tissue grown under salt stress.
17. **Final Practical examination**

LEARNING OUTCOME

After completion of this course students are expected to have knowledge and insight into the physiological and molecular responses of plants to abiotic stresses and adaptive mechanisms of plants against various abiotic stresses.

SUGGESTED READING

1. Plant Physiology Book by Eduardo Zeiger and Lincoln Taiz.
2. Plant physiology Book by Frank B. Salisbury, Cleon W. Ross Salisbury, Frank B Pereira A (2016). Plant Abiotic Stress Challenges from the Changing Environment. Front. Plant Sci.7: 1123.doi:10.3389/fpls.2016.01123
3. SergeyShabala,2012. Plant Stress Physiology.
4. Abid,M., Ali, S.,Qi, L.K., Zahoor, R., Tian, Z., Jiang,D., Snider, J.L. and Dai, T.,2018. Physiological and biochemical changes during drought and recovery periods attillering and jointing stages in wheat (Triticum aestivum L.). Scientific reports, 8(1), p.4615.
5. Fathi, Amin and Barari, Davood. (2016). Effect of Drought Stress and its Mechanismin Plants. International Journal of Life Sciences. 10.1.10.3126/ijls.v10i1.14509.
6. Ashwani Pareek, Sopory. S.K, Bohnert.H.J and Govindjee2010.AbioticStressAdaptationin Plants, Springer, The Netherlands
7. Dumont, S. and Rivoal, J., 2019. Consequences of oxidative stress on plant glycolytic and respiratory metabolism. Frontiers in plantscience,10.
8. Mittler, R., 2002. Oxidative stress, antioxidants and stress tolerance. Trends in plant science,7(9), pp.405-410.
9. Demidchik, V.,2015. Mechanisms of oxidative stress in plants: from classical chemistry to cellbiology. Environmental and experimental botany, 109, pp.212-228.
10. Das, K. and Roy choudhury, A., 2014. Reactive oxygen species (ROS) and response of antioxidants as ROS-scavengers during environmental stressinplants. Frontiers in Environmental Science,2, p.53.
11. Yadav, Praduman, Sunil kumar and Veena Jain. (2016). Recent Advances in Plant Stress Physiology. Daya Publishing House, New Delhi.
12. Gyana Ranjan Rout and Anath Bandhu Das. 2013. Molecular Stress physiology of plants. Springer, India.
13. Combined Stresses in Plants Physiological, Molecular, and Biochemical Aspects Editors: Mahalingam, Ramamurthy (Ed.)2015.
14. Lata, Charu and Muthamilarasan, Mehanathan and Prasad, Manoj. (2015). Drought Stress Responses and Signal Transduction in Plants. In elucidation of abiotic stress signaling in plants (PP.195-225). Springer, New York, Ny. DOI: 10.1007/978-1-4939-2540-7_7.
15. Zhu, J.K., 2016. Abiotic stress signaling and responses in plants. Cell, 167(2), pp.313-324.

16. Osakabe, Y., Yamaguchi-Shinozaki, K., Shinozaki, K. and Tran, L.S.P., 2013.Sensing the environment: key roles of membrane - localized kinases in plant perception and response to abiotic stress. Journal of experimental botany,64(2), pp.445-458.
17. Xiong, L. and Zhu, J.K.,2001. Abiotic stress signal transduction in plants: molecular and genetic perspectives. Physiologiaplantarum,112(2), pp.152-166.
18. Gill, S.S., Anjum, N.A., Gill, R.and Tuteja, N., 2016.Abiotic Stress signaling in plants–an overview. Abiotic Stress Response in Plants,3, pp.1-12.
19. de Vasconcelos, M.W.P.L., Menguer, P.K., Hu, Y., Revers, L.F. and Sperotto, R.A., 2016. Stress signaling responses in plants. Bio Med research international,2016.
20. Khan, A., Pan, X., Najeeb, U., Tan, D.K.Y., Fahad, S., Zahoor, R. and Luo, H., 2018. Coping with drought: stress and adaptive mechanisms, and management through cultural and molecular alternatives in cotton asvital constituents for plant stress resilience and fitness. Biological research,51(1),p.47.
21. Abobatta, Waleed. (2019). Drought adaptive mechanisms of plants-are view. Adv. Agr. Environ Sci.,2(1). 42-45. DOI :10.30881/aaeoa.00021.
22. Basu, S., Ramegowda, V., Kumar, A. and Pereira, A.,2016. Plant adaptation to drought stress. F1000 Research, 5.
23. Gilbert, M.E. and Medina, V., 2016. Drought adaptation mechanisms should guide experimental design. Trend sinplantscience,21(8), pp.639-647.
24. Kamanga RM, Mbega E, Ndakidem Ip (2018) Drought Tolerance Mechanisms in Plants: Physiological Responses Associated with Water Deficit Stressin *Solanumly copersicum*. Adv Crop Sci Tech 6: 362. DOI:10.4172/2329-8863.1000362
25. Farrant, Jilland Cooper, Keren and Nell, J. (2012). Desiccation tolerance.

Drought Stress Tolerance in Plants, Vol1, Physiology and Biochemistry, Editors: Hossain, M.A., Wani, S.H., Bhattacharjee, S., Burritt, D.J., Tran, L.-S.P.(Eds.)

26. Prakash, M. and Dr. K. Balakrishnan. 2014. Abiotic Stress tolerance in crop plants. Satish Serial Publishing House. Delhi. ISBN: 978-93-81226-92-6.
27. Plant Tolerance to Individual and Concurrent Stresses Editors: Senthil-Kumar, Muthappa (Ed.) 2017.
28. Fernando, V.D. and Schroeder, D.F., 2016. Role of ABA in Arabidopsis salt, drought, and desiccation tolerance. In Abiotic and Biotic Stress in Plants-Recent Advances and Future Perspectives. Intech Open.
29. Le Gall, H., Philippe, F., Domon, J.M., Gillet, F., Pelloux, J. and Rayon, C., 2015. Cell wall metabolism in response to abioticstress. Plants, 4(1), pp.112-166.
30. Hasanuzzaman, M., Nahar, K., Alam, M., Roychowdhury, R. and Fujita, M., 2013.
31. Physiological, biochemical, and molecular mechanisms of heatstress tolerance in plants. International journal of molecular sciences,14(5), pp.9643-9684.
32. Khan, M.I.R., Fatma, M., Per, T.S., Anjum, N.A. and Khan, N.A., 2015. Salicylicacid-induced abiotic stress tolerance and under lying mechanisms in plants. Frontiers in Plant Science, 6, p. 462.Tuberosa, Roberto and Salvi, Silvio. (2006). Genomic based approaches to improved rought tolerance in crops. Trends Plant Sci.11.1260-1285.

33. Ali, A., Ali, Z., Quraishi, U.M., Kazi, A.G., Malik, R.N., Sher, H. and Mujeeb-Kazi, A.,2014. Integrating physiological and genetic approaches for improving rought tolerance in crops. In Emerging technologies and management of crop stress tolerance (pp.315-345). Academic Press.
34. Sahebi, M., Hanafi, M.M., Rafii, M.Y., Mahmud, T.M.M., Azizi, P., Osman, M., Abiri, R., Taheri, S., Kalhori, N., Shabanimofrad, M. and Miah, G., 2018.Improvement of drought tolerance in rice (Oryza sativa L.): Genetics, genomic tools, and the WRKY genefamily. Bio Medresear chinternational,2018.
35.Manavalan, L.P., Guttikonda, S.K., Phan Tran, L.S. and Nguyen, H.T., 2009.Physiological and molecular approaches to improve drought resistance in soybean. Plant and Cell Physiology,50(7), pp. 1260-1276.
36.Shah, A.A., Salgotra, R.K., Wani, S.A. and Mondal, S.K., 2017.Breedingandgenomics approaches to increase crop yield under drought stress in climate change scenario. European Journal of Experimental Biology,7(4), pp.1-7.
37.Dixit, S., Yadaw, R.B., Mishra, K.K. and Kumar, A., 2017.Marker-assisted breeding to develop the drought-tolerant version of Sabitri, a popular variety fromNepal.Euphytica,213(8), p.184.
38.Mir, R.R., Zaman-Allah, M., Sreenivasulu, N., Trethowan, R.and Varshney, R.K., 2012. Integrated genomics, physiology and breeding approaches for improving drought tolerance in crops. Theoretical and Applied Genetics,125 (4), pp.625-645.
39.Singla-Pareek, S.L., Reddy, M.K. and Sopory, S.K., 2001. Transgenic approach towards developing abiotics tress tolerance in plants. Proceedings: Indian National Science Academy PartB,67(5), pp.265-284.
40. Gupta, B. and Huang, B., 2014. Mechanism of salinity tolerance in plants: physiological, biochemical, and molecular characterization. International journal of genomics,2014.
41. Zhu, J.K., 2001. Plant salt tolerance. Trendsinplantscience,6(2), pp.66 -71.
Moghimi, A., Yang, C., Miller, M.E., Kianian, S.F. and Marchetto, P.M., 2018. Anovel approach to assess salt stress tolerance in wheat using hyper spectralimaging. Frontiers in plant science,9.
42. Isayenkov, S.V. and Maathuis, F.J., 2019. Plant Salinity Stress: Many Unanswered Questions Remain. Frontiers in plant science,10.
43. Tuteja, N., 2007.Mechanisms of high salinity tolerance in plants. In Methods in enzymology (Vol.428, pp.419-438). Academic Press.
44. Carillo, P., Annunziata, M.G., Pontecorvo, G., Fuggi, A. and Woodrow, P., 2011. Salinity stress and salt tolerance. In Abiotic stress in plants mechanisms and adaptations. Intech Open.
45. Rasool, Saiema and Hameed, Asiya and Azooz, Mohamed and Rehman, Muneeband O. Siddiqi, Tand Ahmad, Parvaiz. (2013). Salt Stress: Causes, Types and Responses of Plants.10.1007/978-1-4614-4747-4_1.
46. Negrão, S., Schmöckel, S.M. and Tester, M., 2017. Evaluating physiological responses of plants to salinity stress. Annals of Botany,119(1), pp.1-11.

47. Fukao, T., Barrera - Figueroa, B.E., J untawong, P. and Peña-Castro, J.M., 2019.Submergence and Water logging Stress in Plants: A Review Highlighting Research Opportunities and Under studied Aspects. Frontiers in Plant Science,10,p.340.
48. Emamverdian, A., Ding, Y., Mokhberdoran, F. and Xie, Y., 2015. Heavy metal stress and some mechanisms of plant defense response. TheScientificWorldJournal,2015.
49. Mani, A. and Sankaranarayanan, K., 2018.Heavy Metal and Mineral Element-Induced Abiotic Stress in Rice Plant. In Rice Crop-Current Developments. IntechOpen.
50. Barceló, Juan and Poschenrieder, Charlotte. (2008). Plant Water Relations as Affected by Heavy Metal Stress: A Review. Journal of Plant Nutrition.13.1-37.10.1080 / 01904169009364057.
51. Regulation of root traits for internal aeration and tolerance to soil water logging-flooding stress. Takaki Yamauchi, Timothy D. Colmer, OlePedersen, Mikio Nakazono, Plant physiology, 2018,176 (2) 1118-1130.DOI:10.1104/pp.17.01157.
52. Szymańska, R., Ślesak, I., Orzechowska, A. and Kruk, J., 2017.Physiological and biochemical responses to highlight and temperature stress in plants. Environmental and Experimental Botany,139, pp.165-177.
53. Maduraimuthu, Djanaguiraman and Prasad, P.V.Vara. (2014). High temperature stress.
54. Nahar, K., Hasanuzzaman, M., Ahamed, K.U., Hakeem, K.R., Ozturk, M.and Fujita, M., 2015. Plant responses and tolerance to high temperature stress: role of exogenousphy to protectants. In Crop production and global environmental issues (pp. 385-435). Springer, Cham.
55. Mathur, S., Agrawal, D. and Jajoo,A.,2014. Photosynthesis: response to high temperature stress. Journal of Photo chemistry and Photobiology B: Biology, 137, pp.116-126.
56. Ort, D.R., 2001. When the reistoo much light. Plant physiology, 125 (1), pp.29-32.
57. Demmig-Adams, B. and AdamsIii, W.W., 1992.Photoprotection and other responses of plants to highlight stress. Annual review of plant biology, 43 (1), pp.599-626.
58. Dietz, K.J., 2015. Efficient high light acclimation involves rapid processes at multiple mechanistic levels. Journal of Experimental Botany, 66(9), pp.2401-2414.

SUGGESTED WEBSITE

1. https://www.mapsofindia.com/maps/india/drought-prone-areas.html
2. http://threeissues.sdsu.edu/three_issues_droughtfacts03.html

MBB 504 Techniques in Molecular Biology 1+2

AIM OF THE COURSE

To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology. To get a hands on training in Chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics.

THEORY

Unit I

Good lab practices and preparation of buffers and reagents, Principles of centrifugation and spectrophotometry, Growth of bacterial culture and preparation of culture.

Unit II

Isolation of genomic and plasmid DNA from bacteria. Growth of lambda phage and its isolation. Isolation of and restriction of plant DNA. Quantification of DNA by Agarose Gel electrophoresis and by Spectrophotometry.

Unit III

PCR using isolated DNA, PAGE Gel Electrophoresis, Restriction digestion of plasmid and phage DNA, ligation and Recombinant DNA construction.

Unit IV

PAGE Gel Electrophoresis. Restriction digestion of plasmid and phage DNA, Ligation and Recombinant DNA construction. Transformation of *E. coli* and Selection of transformants.

Unit V

TLC and Gel filtration Chromatographic techniques. Ion exchange Chromatography and Affinity Chromatography. Dot blot analysis and Southern hybridization, Northern hybridization, Western blotting and ELISA technique. Radiation safety Procedures and non-radio isotopic procedure.

PRACTICAL

Good lab practices, Preparation of buffers and reagents. Principle of centrifugation, Principles of spectrophotometry. Growth of bacterial culture. Preparation of growth curve. Isolation of Genomic DNA from bacteria. Isolation of plasmid DNA from bacteria. Growth of lambda phage. Isolation of phage DNA. Isolation and restriction of plant DNA in Rice. Isolation and restriction of plant DNA in Moong. Isolation and restriction of plant DNA in Mango. Isolation and restriction of plant DNA in Merigold. Quantification of DNA by Agarose Gel electrophoresis. Quantification of DNA by Spectrophotometry. PCR using isolated DNA. PAGE Gel electrophoresis. Restriction digestion of plasmid and phage DNA. Ligation of Phage DNA. Recombinant DNA construction. Transformation of *E. coli* .Selection of transformants. TLC Chromatographic techniques. Gel Filtration Chromatography. Ion exchange Chromatography, Affinity Chromatography. Dot blot analysis, Southern hybridization, Northern hybridization. Western blotting. ELISA technique.Radiation safety Procedures and non-radio isotopic procedure.

LECTURE SCHEDULE

1. Good lab practices and preparation of buffers and reagents
2. Principles of centrifugation and spectrophotometry
3. Growth of bacterial culture and preparation of culture

4. Isolation of genomic and plasmid DNA from bacteria
5. Growth of lambda phage and its isolation
6. Isolation of and restriction of plant DNA
7. Quantification of DNA by Agarose Gel electrophoresis and by Spectrophotometry
8. PCR using isolated DNA and PAGE Gel Electrophoresis
9. Mid-semester examination
10. Restriction digestion of plasmid and phage DNA, ligation and Recombinant DNA construction.
11. Transformation of *E. coli and* Selection of transformants
12. TLC and Gel filtration Chromatographic techniques
13. Ion exchange Chromatography and Affinity Chromatography
14. Dot blot analysis and Southern hybridization,
15. Northern hybridization, Western blotting and ELISA technique.
16. Radiation safety Procedures and non-radio isotopic procedure.
17. Final theory Examination

PRACTICAL SCHEDULE

1. Good lab practices,
2. Preparation of buffers and reagents.
3. Principle of centrifugation
4. Principles of spectrophotometry.
5. Growth of bacterial culture
6. Preparation of growth curve
7. Isolation of Genomic DNA from bacteria.
8. Isolation of plasmid DNA from bacteria.
9. Growth of lambda phage
10. Isolation of phage DNA.
11. Isolation and restriction of plant DNA in Rice
12. Isolation and restriction of plant DNA in Moong
13. Isolation and restriction of plant DNA in Mango
14. Isolation and restriction of plant DNA in Merigold.
15. Quantification of DNA by Agarose Gel electrophoresis
16. Quantification of DNA by Spectrophotometry
17. PCR using isolated DNA.
18. PAGE Gel electrophoresis.
19. Restriction digestion of plasmid and phage DNA
20. Ligation of Phage DNA
21. Recombinant DNA construction.
22. Transformation of *E. coli*
23. Selection of transformants
24. TLC Chromatographic techniques
25. Gel Filtration Chromatography,
26. Ion exchange Chromatography,

27. Affinity Chromatography
28. Dot blot analysis,
29. Southern hybridization,
30. Northern hybridization.
31. Western blotting
32. ELISA technique.
33. Radiation safety Procedures and non-radio isotopic procedure.
34. Final practical examination

LEARNING OUTCOME

Towards making the students competent to pursue MSc. thesis research in the field of Plant molecular biology.

SUGGESTED READING

1. Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA and Struhl K. 2002. *Short Protocols in Molecular Biology* 5th edition, Current Protocols publication.
2. Sambrook, J., and Russell, R.W. 2001. *Molecular Cloning: A Laboratory Manual* 3rd Edition, Cold spring harbor laboratory press, New York.
3. Wilson, K., and Walker, J., 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th edition, Cambridge University Press.

MBB 505 Omics and Systems Biology 2+1

AIM OF THE COURSE

To get a basic overview of genomics, proteomics, ionomics and metabolomics. To get a primary information on the application of omics science across the industry.

THEORY

Unit I

Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary. Genomics, Organelle genomics, applications in phylogenetics, case studies of completed. genomes, preliminary genome data analysis, basics of ionomics analysis, different methods.

Unit II

Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry, Proteomics: Gel based and gel free, Basics of software used in proteomics, MASCOT, PD-Quest, etc., Study of protein interactions, Prokaryotic and yeast-based expression system and purification

Unit III

Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of

ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA), Data Integration using genome, transcriptome, proteome, metabolome and ionome with phenome.

Unit IV

Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, Equilibrium binding and cooperatively – Michaelis- Menten Kinetics, Biological oscillators, Genetic oscillators, Quorum Sensing,

Unit V

Cell to cell communication, *Drosophila* Development, Pathways to Network, Gene regulation at a single cell level, transcription network, Regulatory Circuits, Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis

PRACTICAL

Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis. BSA Standard curve preparation, Extraction of protein and estimation methods. Quantification of proteins from different plant tissues using spectrophotometry.2-D Gel Electrophoresis, 2-D Image analysis. Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system). Demonstration on MALDI-TOF.Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

LECTURE SCHEDULE

1. Different methods of genome sequencing,
2. Principles of various sequencing chemistries,
3. Physical and genetic maps,
4. Comparative and evolutionary Genomics,
5. Organelle genomics, applications in phylogenetics, case studies of completed genomes,
6. Preliminary genome data analysis,
7. Basics of ionomics analysis, different methods.
8. Protein-basics: primary-, secondary- and tertiary structure,
9. Basics of X-ray crystallography and NMR,
10. Principal and Applications of mass spectrometry,
11. Proteomics: Gel based and gel free,
12. Basics of software used in proteomics, MASCOT, PD-Quest, etc.,
13. Study of protein interactions, Prokaryotic and yeast-based expression system and purification.
14. Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis,
15. Multivariate analysis and identification of metabolite as biomarkers,
16. Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS),
17. **Mid Semester Examination**
18. X-Ray Fluorescence (XRF),
19. Neutron activation analysis (NAA),

20. Data Integration using genome, transcriptome, proteome, metabolome and ionome with phenome.
21. Introductory systems Biology –
22. The biochemical models, genetic models and systems model,
23. Molecules to Pathway,
24. Equilibrium binding and cooperatively – Michaelis- Menten Kinetics,
25. Biological oscillators, Genetic oscillators, Quorum Sensing.
26. Cell to cell communication,
27. *Drosophila* Development,
28. Pathways to Network,
29. Gene regulation at a single cell level,
30. Transcription network, REGULATORY CIRCUITS,
31. Negative and positive auto-regulation,
32. Alternative Stable States,
33. Bimodal Switches,
34. Network building and analysis

PRACTICAL SCHEDULE

1. Isolation of HMW DNA
2. Overview of sequencing,
3. Primary information on genome data analysis.
4. BSA Standard curve preparation,
5. Extraction of protein and estimation methods.
6. Quantification of proteins from different plant tissues using spectrophotometry.
7. 2-D Gel Electrophoresis,
8. 2-D Image analysis.
9. Experiments on protein-protein interaction (Yeast 2-hybrid)
10. Experiments on protein-protein interaction (Split Ubiquitinsystem).
11. Demonstration on MALDI-TOF.
12. Demonstration on ICP-MS,
13. Demonstration on AAS,
14. Nitrogen estimation using Kjeldahl methods
15. Nitrogen estimation using Dumas methods
16. Nitrogen estimation using Combustion methods
17. **Final Practical exam**

LEARNING OUTCOME

Students should be able to appreciate how interactions between genes can explain some of the behaviour in the cells at different levels using Omics approaches.

SUGGESTED READING

1. Primrose, S.B. and Twyman, R. 2006. *Principles of Gene Manipulation* 7th edition, Wiley Blackwell.
2. Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

MBB 506 Plant Genetic Engineering 3+0

AIM OF THE COURSE

To get a basic overview of molecular cloning, vectors and genomic library construction. To get an overview of PCR and its applications, sequencing, gene knockouts, transgenics *etc*.

THEORY

Unit I

Historical background, Restriction Enzymes; DNA Modifying enzymes, ligase, T4 DNA polymerase, Polynucleotide kinaseetc, Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immuno precipitation; DNA-Protein Interactions: Electromobility shift assay.

Unit II

Plasmids; Bacteriophages; M13, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal,pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag, etc.; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors.

Unit III

Transformation; Construction of libraries; Isolation of mRNA and total RNA; Cdna and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques.

Unit IV

Principles of PCR, Primer design, DNA polymerases, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T- vectors; Applications of PCR in gene recombination, Site specific mutagenesis, in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.

Unit V

Genetic transformation of plants: DNA delivery – *Agrobacterium* mediated method. Direct DNA delivery – chemical mediated electroporation and particle bombardment. Vectors and transgene design - Promoters and Marker genes. Chloroplast transformation. Development of marker-free plants. Analysis of transgenic plants – molecular and Biochemical assays, genetic analysis - Identification of gene integration site - Advance methods – *cis* genesis, intragenesis and targeted genome modification – ZFN, TALENS and CRISPR. Application of transgenic technology.

LECTURE SCHEDULE

1. Historical background of Plant Genetic Engineering.
2. Restriction Enzymes;
3. DNA Modifying enzymes, DNA ligase,
4. T4 DNA polymerase, Polynucleotide kinase *etc*,
5. Cohesive and blunt end ligation; Labeling of DNA: Nick translation,
6. Random priming,
7. Radioactive and non-radioactive probes,
8. Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization;
9. Chromatin Immuno-precipitation;
10. DNA-Protein Interactions: Electromobility shift assay.
11. Plasmids; Bacteriophages; M13, Phagemids;
12. Lambda vectors; Insertion and Replacement vectors;
13. Cosmids; Artificial chromosome vectors (YACs; BACs);
14. Animal Virus derived vectors-SV-40;
15. Expression vectors; pMal, pET-based vectors;
16. Protein purification; His-tag; GST-tag; MBP-tag, etc.;
17. Baculovirus vectors system,
18. Plant based vectors, Ti and Ri plasmids as vectors,
19. Yeast vectors, Shuttle vectors.
20. Transformation; Construction of libraries;
21. Isolation of mRNA and total RNA;
22. Cdna and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries,
23. Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression
24. Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques.
25. Mid-semester Examination
26. Principles of PCR, Primer design, DNApolymerases,
27. Types of PCR – multiplex, nested,
28. Reverse transcriptase,
29. Real time PCR, touchdown PCR,

30. Hot start PCR, Colony PCR,
31. Cloning of PCR products;
32. T- vectors;
33. Applications of PCR in gene recombination,
34. Site specific mutagenesis, in molecular diagnostics;
35. Viral and bacterial detection;
36. Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.
37. Genetic transformation of plants: DNA delivery – *Agrobacterium* mediated method.
38. Direct DNA delivery – chemical mediated electroporation.
39. Direct DNA delivery and particle bombardment.
40. Vectors and transgene design - Promoters and Marker genes.
41. Chloroplast transformation.
42. Development of marker-free plants.
43. Analysis of transgenic plants – molecular and Biochemical assays,
44. Genetic analysis of transgenic plants.
45. Identification of gene integration site –
46. Advance methods – *cis* genesis, intragenesis and
47. Targeted genome modification – ZFN, TALENS and CRISPR.
48. Application of transgenic technology.

LEARNING OUTCOME

By the end of this course, students will be able to describe different tools and techniques of rDNA technology and explain the process of developing genetically improving crop varieties through transgenic and genome editing technologies.

SUGGESTED READING

- Brown, T.A. 2010. *Gene Cloning and DNA Analysis an Introduction.* 6th edition, Wiley Blackwel.
- Primrose, S.B. and Twyman, R. 2006. *Principles of Gene Manipulation* 7th edition, Wiley Blackwell.
- Sambrook, J., and Russell, R.W. 2001. *Molecular cloning: A laboratory manual* 3rd Edition, Cold spring harbor laboratory press, New York.
- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

MBB 509 Plant Tissue Culture 2+1

AIM OF THE COURSE

To provide insight into principles of plant cell culture and genetic transformation. To get a hands on training in basic plant tissue culture techniques, callusing, micropropagation and analysis.

THEORY

Unit I

History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture.

Unit II

National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA. Micro-propagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micro grafting; Androgenesis and gynogenesis - production of androgenic and gynogenic haploids – diploidization.

Unit III

Protoplast culture -isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization - Production of Somatic hybrids and Cybrid. Wide hybridization - embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture.

Unit IV

Large-scale cell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations – causes and applications;

Unit V

Callus culture and *in vitro* screening for stress tolerance; Artificial seeds*, In vitro* germplasm storage and cryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government Policies.

PRACTICAL

Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium. Micro-propagation of plants by nodal and shoot tip culture. Embryo culture to overcome incompatibility, Anther culture for haploid production. Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis. Acclimatization of tissue culture plants and establishment in greenhouse. Virus indexing in tissue culture plants.(Using PCR and ELISA).Plan of a commercial tissue culture unit.

LECTURE SCHEDULE

1. History of plant tissue culture, principle of Totipotency.
2. Tissue culture media;
3. Plant hormones and morphogenesis;
4. Direct and indirect organogenesis;
5. Direct and indirect somatic embryogenesis;

6. Applications of plant tissue culture.
7. National certification and Quality management of TC plants.
8. Genetic Fidelity testing and Virus indexing methods – PCR, ELISA.
9. Micropropagation of field and ornamental crops.
10. Virus elimination by meristem culture, meristem tip culture and micro grafting.
11. Androgenesis and gynogenesis - production of androgenic and gynogenic haploids – diploidization.
12. Protoplast culture -isolation
13. Protoplast purification.
14. Protoplast culture.
15. Protoplast fusion;
16. Somatic hybridization - Production of Somatic hybrids and Cybrid.
17. **Mid semester examination**
18. Wide hybridization – embryo culture and embryo rescue techniques.
19. Ovule, ovary culture and endosperm culture.
20. Large-scale cell suspension culture.
21. Production of alkaloids and other secondary metabolites.
22. Techniques to enhance secondary metabolite production,
23. Somaclonal and gametoclonal variations – causes and applications.
24. Callus culture and *in vitro* screening for stress tolerance;
25. Artificial seeds,
26. *In vitro* germplasm storage and cryo-preservation.
27. Commercial Tissue Culture
28. Case studies and success stories- Commercial unit I
29. Case studies and success stories- Commercial unit II.
30. Case studies and success stories- Commercial unit III.
31. Market assessment of Commercial tissue culture.
32. Project planning and preparation, economics,
33. Government Policies on Plant Tissue culture.
34. **Final Theory Examination**

PRACTICAL SCHEDULE

1. Preparation of stocks - macronutrients, micronutrients, vitamins and hormones,
2. Filter sterilization of hormones and antibiotics.
3. Preparation of Murashige and Skoog medium.
4. Micro-propagation of Banana.
5. Micropropagation of Neam
6. Micro-propagation of Rose.
7. Embryo culture to overcome incompatibility.
8. Anther culture for haploid production.
9. Callus induction in tobacco leaf discs,
10. Regeneration of shoots, root induction, role of hormones in morphogenesis.
11. Acclimatization of tissue culture plants and establishment in greenhouse.

12. Virus indexing in tissue culture plants Using PCR.
13. Virus Indexing using ELISA.
14. Plan of a commercial tissue culture unit.
15. Visit to a commercial Tissue culture lab.
16. Visit to a National Institute involved in tissue culture.
17. Final Practical examination.

LEARNING OUTCOME

Students should be able to acquire comprehensive knowledge on plant tissue culture, techniques of multiplication and establishment of plants, value addition through various techniques related to plant tissue culture. Further, the students would be exposed to preparation of project to establish a commercial PTC lab, and understand operational guidelines for production, certification, marketing management of tissue culture plants and its products.

SUGGESTED READING

1. Razdan, M.K. 2003. *Introduction to plant tissue culture*, 2nd edition, Oxford publications group
2. Butenko, R.G. 2000. *Plant Cell Culture* University Press of Pacific
3. Herman, E.B. 2008. *Media and Techniques for Growth, Regeneration and Storage*, Agritech Publications, New York, USA.
4. Bhojwani, S.S and Dantu P. 2013. *Plant Tissue Culture – An Introductory Text*. Springer Publications.
5. Gamborg, O.L and G.C. Philips (eds.). 2013. *Plant Cell, Tissue and Organ culture-Lab Manual*. Springer Science & Business media.

SST 503 Seed Production Principles and Techniques in Field Crops 2+1

WHY THIS COURSE?

Awareness about the use of quality seed among farmers to enhances the seed demand and seed trade. To meet the seed demand, production should be carried out in large areas. Hence, it is essential to learn about the production principles and techniques of quality seed production.

AIM OF THE COURSE

To impart knowledge on principles and practices involved in quality seed production of field crops.

THEORY

Unit I

Importance of seed - seed quality - concept - factors influencing seed production; classes of seed - generation system of seed multiplication - stages of seed multiplication in

varieties and hybrids - seed multiplication ratio (SMR) - seed replacement rate (SRR) - seed renewal period (SRP) - varietal replacement rate (VRR).

Unit II

Genetic and agronomic principles of variety and hybrid seed production; nucleus and breeder seed production techniques and their maintenance; methods and techniques of seed production in varieties and hybrids of important cereals and millets - wheat, rice, maize, sorghum and pearl millet; varietal seed production in small millets - finger millet, fox tail millet, kodo millet, proso millet and barnyard millet.

Unit III

Methods and techniques of varietal seed production in major pulses - black gram, green gram, cowpea, chickpea, horse gram, soybean and lentil - varietal and hybrid seed production in red gram.

Unit IV

Methods and techniques of seed production in major oil seed crops - groundnut, sesame - varietal and hybrid seed production in sunflower, castor and mustard; varietal seed production in minor oilseed crops (safflower, linseed, niger) - varietal and hybrid seed production in cotton - varietal seed production in jute; seed and planting material production techniques in sugarcane.

Unit V

Seed production planning - criteria for selection of season, variety, location, infrastructure facilities; farmers participatory seed production - seed hubs, seed village concept and community seed bank.

PRACTICAL

Criteria for seed selection on field establishment - sowing and nursery management techniques - seedling age on crop establishment - isolation distance - space and barrier isolation - planting design for hybrid seed production - detasseling, emasculation and dusting - methods of achieving synchronization - supplementary pollination - identification of off-types - roguing operation - estimation of seed shattering loss; in-situ germination and loss; visit to seed production fields; visit to seed industry; seed production planning for varieties and hybrids; economics of varietal and hybrid seed production.

LECTURE SCHEDULE

1. Seed and its importance in agriculture and concept of seed quality
2. Biotic and abiotic factors influencing seed production
3. Different classes of seed and generation system of seed multiplication
4. Stages of seed multiplication and maintenance of parental lines in hybrids
5. Seed Multiplication Ratio (SMR) and Seed Replacement Rate (SRR) and their significance
6. Seed Renewal Period (SRP) and Varietal Replacement Rate (VRR) and their significance
7. Genetic and agronomic principles of variety and hybrid seed production

8. Nucleus seed production techniques and its maintenance
9. Breeder seed production techniques and its maintenance
10. Principles and techniques of seed production in varieties and hybrids of wheat
11. Principles and techniques of seed production in rice varieties
12. Principles and techniques of seed production in rice hybrids
13. Principles and techniques of seed production in maize varieties and hybrids
14. Principles and techniques of seed production in varieties and hybrids of sorghum
15. Principles and techniques of seed production in varieties and hybrids of pearl millet
16. Principles and techniques of varietal seed production in small millets - finger millet and fox tail millet
17. **Mid semester examination**
18. Principles and techniques of varietal seed production in small millets - kodo millet, prosomillet and barnyard millet
19. Principles and techniques of seed production in black gram, green gram and cowpea varieties
20. Principles and techniques of varietal seed production in chickpea and horse gram
21. Principles and techniques of varietal seed production in soybean and lentil
22. Principles and techniques of varietal and hybrid seed production in red gram
23. Principles and techniques of varietal seed production in groundnut
24. Principles and techniques of varietal seed production in sesame
25. Principles and techniques of varietal and hybrid seed production in sunflower
26. Principles and techniques of varietal and hybrid seed production in castor
27. Principles and techniques of varietal and hybrid seed production in mustard
28. Principles and techniques of varietal seed production in minor oilseed crops- safflower, linseed and niger
29. Principles and techniques of varietal and hybrid seed production in cotton
30. Principles and techniques of varietal seed production in jute
31. Seed and planting material production techniques in sugarcane
32. Planning for seed production programme - criteria for selection of season, variety and location infrastructure facilities
33. Farmers participatory seed production through seed hubs and seed village concept
34. Role of community seed bank in India

PRACTICAL SCHEDULE

1. Selection criteria for quality seed and its effect on field establishment
2. Practicing sowing and nursery management techniques
3. Study on the effect of seedling age on crop establishment in rice
4. Study on space and barrier isolation for seed production
5. Planting design for hybrid seed production in rice, maize and pearl millet
6. Planting design for hybrid seed production in cotton, red gram and sunflower
7. Practicing detasseling technique for hybrid seed production in maize
8. Practicing emasculation and dusting for hybrid seed production in cotton
9. Study on methods of achieving synchronization in rice, bajra and sunflower

10. Practicing supplementary pollination in rice and sunflower
11. Identification of off types - pollen shedders, shedding tassels, partials, selfed bolls and practicing roguing operation
12. Estimation of seed shattering loss and study on in-situ germination
13. Visit to seed production fields
14. Visit to seed industry
15. Seed production planning for varieties and hybrids
16. Economics of varietal and hybrid seed production
17 **Final practical examination**

LEARNING OUTCOME

Successful completion of this course enable student to take up seed production venture in scientific manner to ensure seed quality and profitability.

SUGGESTED READING

1 Singhal, N. C. 2003.Hybrid Seed Production in Field Crops. Kalyani Publications, New Delhi.
2 Joshi, A. K. and Singh, B. D. 2004. Seed Science and Technology. Kalyani Publishers, New Delhi.
3 Kulkarni, G. N. 2011.Principles of Seed Technology. Kalyani Publishers, New Delhi.
4 Singhal, N. C. 2010.Seed Science and Technology. Kalyani Publishers, New Delhi.
5 Sen, S. and Ghosh, N. 2010.Seed Science and Technology. Kalyani Publishers, New Delhi.
6 Mondal, S.S., Saha, M. and Sengupta, K. 2009.Seed Production of Field Crops. New India Publishing Agency, New Delhi.
7 Hebblethwaite, P. D. 1980. Seed Production. Butterworth Heinemann Ltd., London, UK.
8 Agrawal, R.L. 2019.Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.
9 McDonald, M.B. and Copeland, L. 1998. Seed Production Principles and Practices. CBSPublishers, New Delhi.
10 Maiti, R.K., Sarkar, N.C. and Singh, V.P. 2006.Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan.
11 Chowdhury, R.K. and Lal, S.K. 2003. Nucleus and breeder seed production manual, National Seed Project (Crops), ICAR, New Delhi.

SUGGESTED WEBSITE

1 https://agriinfo.in/botany/18/
2 http://www.fao.org/3/a-e8935e.pdf
3 http://www.agriquest.info/seed_production.php
4 http://agritech.tnau.ac.in/seed_certification/seedtech_index.html
5 http://coin.fao.org/coinstatic/cms/media/16/13666518481740/seed_enterprises nt_and_development_project_in_sierra_leone_mission_1_report_.pdf

SST 508 POST HARVEST HANDLING AND STORAGE OF SEEDS 2+1

WHY THIS COURSE?

Healthy seeds are the demanding enterprise of the recent era for the production of high yield in the next season. The seeds must be well processed and stored for the maintenance of high- yielding crop. During storage, major losses of seeds are caused by various biotic and abiotic factors. There is a need to apply proper post-harvest handling and storage techniques, which ultimately improve the market value and quality of the seed.

AIM OF THE COURSE

To impart knowledge on principles, techniques and methods of seed processing, treatment and storage.

THEORY

Unit I

Seed processing - objectives and principles; processing sequence - threshing, shelling, ginning, extraction methods; drying - principles and methods; seed cleaning, grading, upgrading - methods - machineries and equipments - scalper, pre-cleaner, cleaner cum grader, specific gravity separator, indented cylinder, disc separator, spiral separator, velvet separator, magnetic separator, needle separator and electronic colour sorter - working principles and functions.

Unit II

Online seed processing - elevators and conveyers - processing plant - specifications, design and layout; mechanical injury - causes and detection - management.

Unit III

Seed treatment - methods - pre and mid storage seed treatments, seed treating formulations and equipments; packaging materials - types - bagging and labeling; seed blending - principle and method.

Unit IV

Seed storage - purpose and importance - factors affecting storage, optimum condition for storage of different seeds; storage principles - Harrington's thumb rule - concepts and significance of moisture equilibrium - maintenance of safe seed moisture - physical, physiological, biochemical and molecular changes during seed storage - storage behaviour of orthodox and recalcitrant seeds - prediction of viability - viability nomograph.

Unit V

Methods of seed storage - modified atmospheric storage - ultra dry storage - vacuum storage - cryopreservation - germplasm storage - gene banks - Biodiversity International and NBPGR -International and National seed storage facilities; seed storage godown - structures - maintenance - sanitation.

PRACTICAL

Seed extraction - wet and dry methods - seed drying methods - principle and methods - seed processing sequence for different crops - design of processing plant - equipments - estimation of processing efficiency - practicing seed grading and upgrading techniques - delinting methods - assessment of mechanical damage - visit to seed processing unit - seed packaging - effect of packaging materials on seed longevity - prediction of viability during storage - viability nomograph and accelerated ageing test - assessing physical, physiological and biochemical changes during seed storage - study on storage behaviour of recalcitrant seeds - pre-storage seed treatments - protectants - antioxidants - halogens - practicing seed blending methods - visit to seed storage godown and cold storage unit.

LECTURE SCHEDULE

1. Objectives and principles of seed processing
2. Sequence of seed processing for different crops
3. Methods of seed threshing, shelling and ginning
4. Seed extraction methods for different crops
5. Principles and methods of seed drying
6. Methods and machineries for seed cleaning, grading and upgrading
7. Working principles and functions of scalper and pre-cleaner
8. Working principles and functions of cleaner *cum* grader
9. Working principles and functions of specific gravity separator and indented cylinder
10. Working principles and functions of disc separator and spiral separator
11. Working principles and functions of velvet separator and magnetic separator
12. Working principles and functions of needle separator and electronic colour sorter
13. Working principles and functions of elevators and conveyers
14. Specifications, design and layout of processing plant
15. Causes of mechanical injury, detection methods and its management
16. Principles and methods of pre and mid storage seed treatments, seed treating formulations and equipments
17. **Mid semester examination**
18. Types of packaging materials, methods of bagging, labeling and stacking
19. Principle and method of seed blending
20. Importance and stages of seed storage
21. Principles of seed storage and Harrington's thumb rule
22. Factors affecting seed storage and optimum condition for storage of different seeds
23. Influence of seed storage containers on seed longevity
24. Concepts and significance of moisture equilibrium in seed storage environment
25. Study on physical and physiological changes during seed storage
26. Study on biochemical and molecular changes during seed storage
27. Study on storage behaviour of recalcitrant seeds
28. Prediction of seed viability and viability nomograph

29. Controlled and modified atmospheric storage, ultra dry storage and vacuum storage methods
30 Germplasm storage, methods of cold storage and techniques of cryopreservation
31 Guidelines for storage in gene banks, Biodiversity International and NBPGR
32 International and National seed storage facilities
33 Study on seed storage structures
34 Maintenance of seed storage godown

PRACTICAL SCHEDULE

1. Practicing seed extraction methods for different crops
2. Practicing different seed drying methods
3. Study on seed processing sequence for different crops
4. Estimation of processing efficiency of cleaner cum grader
5. Practicing seed grading and upgrading techniques
6. Practicing delinting in cotton
7. Assessment of mechanical damage in different crops
8. Visit to seed processing unit
9. Effect of packaging materials on seed longevity
10. Prediction of seed longevity using viability nomograph and accelerated ageing test
11. Assessing physical and physiological changes in seeds during storage
12. Assessing biochemical changes in seeds during storage
13. Determination of seed longevity in recalcitrant seeds
14. Studying the effect of different pre-storage seed treatments on seed quality
15. Practicing seed blending technique and germination assessment
16. Visit to seed storage godown and cold storage unit
17. **Final practical examination**

LEARNING OUTCOME

The students will understand the principles and mechanism involved in seed processing, storage techniques and management practices to arrest the seed deterioration. Students will also acquire skill on seed handling and storage methods on commercial basis.

SUGGESTED READING

1. Barton, L.V. 1961. Seed Preservation and Longevity, (Vol. 1). Leonard Hill, London.
2. Gregg, B.R, Law, A.G, Virdi, S.S and Balis, J.S. 1970. Seed Processing. Avion Printers, New Delhi.
3. Gupta, D. 2009. Seeds: Their Conservation Principles and Practices. Sathish Serial Publishing House. New Delhi.
4. Justice, O.L. and Bass, L.N. 1978. Principles and Practices of Seed Storage. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.
5. Kulkarni, G. N. 2011.Principles of Seed Technology.Kalyani Publishers, New Delhi.

6. Maiti, R.K., Sarkar, N.C. and Singh, V.P. 2006.Principles of Post Harvest Seed Physiology and Technology.Agrobios, Jodhpur, Rajasthan.
7. Padmavathi, S., Prakash, M., Ezhil Kumar, S., Sathiyanarayanan, G. and Kamaraj, A. 2012. A Text Book of Seed Science and Technology, New India Publishing Agency, New Delhi.
8. Sen, S. and Ghosh, N. 2010.Seed Science and Technology. Kalyani Publishers, New Delhi.
9. Singhal, N. C. 2010.Seed Science and Technology. Kalyani Publishers, New Delhi.
10. http://dfsc.dk/pdf/Handbook/chapter8_internet.pdf.
11. https://naldc.nal.usda.gov/download/CAT87208646/PDF.
12. https://www.springer.com/in/book/9780792373223.
13. http://203.64.245.61/fulltext-pdf/EB/1900-2000/eb0021.pdf.
14. https://www.kopykitab.com/ebooks/2016/05/6997/sample/sample_6997.pdf.
15.https://trove.nla.gov.au/work/6862691?q&sort=holdings+desc&=1541066209257&versionId=45008917+251246346.
16.http://www.worldseed.org/wp-content/uploads/2017/01/Seed-Production-Good-practice 10.01.17-final.pdf

SUGGESTED WEBSITE

1. http://www.fao.org/3/a-ah803e.pdf
2. agritech.tnau.ac.in/seed_certification/seedtech_index.html
3. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=17806
4. http://www.bcseeds.org/wp-content/uploads/2015/01/Seed-Processing 015update.pdf
5.https://www.carolinafarmstewards.org/wpcontent/uploads/2012/05/SeedProcessing andStorageVer_1pt3.pdf

SST 509 Seed Quality Testing and Enhancement 1+1

WHY THIS COURSE?

Seed is the basic input in agriculture and the productivity is mainly depends on field population of plants. By sowing quality seeds, population can be maintained. Hence, it is necessary to know the quality parameters to be analyzed. Through seed treatments, the performance of seed can be improved. Especially to address the drought and climate change the knowledge on seed enhancement techniques is much essential.

AIM OF THE COURSE

To impart knowledge on principles, techniques and methods of seed testing and seed quality enhancement.

THEORY

Unit I

Seed testing - history and development; ISTA and its role in seed testing; seed lot, types of seed samples - sampling - intensity and methods, sampling devices - sub sampling;

purity analysis - components and procedure - determination of other distinguishable varieties (ODV) and test weight determination - heterogeneity test - method of testing coated and pelleted seeds; seed moisture estimation - principles and methods, application of tolerances.

Unit II

Seed germination test - requirements, media and methods - seedling evaluation and reporting results; viability test (TZ test) - principle, procedure and evaluation; vigour tests - concept of seed vigour and vigour test - types of vigour tests - direct and indirect tests - physical, physiological and biochemical tests - principles and methods; seed health test - principles and methods.

Unit III

Genetic purity assessment - laboratory methods - physical, chemical, biochemical and molecular tests - growth chamber and field testing (Grow Out Test) methods; testing of GM seeds; advanced non-destructive techniques of seed quality analysis - soft x-ray imaging - hyper spectral imaging, thermal imaging - spectroscopy - e-nose and machine vision techniques; storage of guard sample- referral test; application of tolerance in seed testing.

Unit IV

Seed quality enhancement techniques - classification - physical, physiological and protective seed treatments - special seed treatments; physical seed treatment - liquid floatation, specific gravity separation, irradiation, electric and electro-magnetic seed treatments - principles and methods - seed pelleting and coating principles, purpose and methods.

Unit V

Physiological seed enhancement treatments - seed infusion, seed priming - principles and methods - physiological, biochemical and molecular mechanisms; biological seed treatments - integrated seed treatment and concept of designer seed.

PRACTICAL

Sampling and dividing methods - determination of seed test weight and heterogeneity test - physical purity analysis - seed moisture estimation - methods and equipments - seed germination test and seedling evaluation - quick viability (tetrazolium) test and evaluation - vigour tests - genetic purity assessment- seed health tests - visit to seed testing laboratory - seed enhancement techniques - physical treatments and water floatation techniques - seed coating and pelleting - seed infusion and seed priming - microbial inoculation - pre-germination technique - integrated seed treatment.

LECTURE SCHEDULE

1. History, concept and role of seed quality testing; ISTA and its role on seed quality
2. Seed lot, sampling intensity and methods of sampling and heterogeneity testing
3. Physical purity analysis, determination of other distinguishable varieties (ODV) and test weight determination

4. Principles and methods of seed moisture estimation
5. Procedures and methods of seed germination test; principle and procedure of viability test
6. Concept of seed vigour and vigour tests; principles and methods of physical, physiological and biochemical vigour tests
7. Principles and methods of seed health testing
8. **Mid semester examination**
9. Principles and procedures of genetic purity assessment
10. Principles and testing procedures for GM seeds
11. Non-destructive techniques of seed quality analysis - soft x-ray, hyper spectral imaging, thermal imaging, spectroscopy, e-nose and machine vision techniques
12. Principles and testing procedures for coated and pelleted; application of tolerance in seed testing; storage of guard sample and referral test
13. Principles and methods of physical seed treatments - specific gravity separation, irradiation, electric and electro-magnetic seed treatments
14. Principles and methods of seed pelleting and coating.
15. Principles and methods of physiological seed treatments - seed infusion and seed priming
16. Physiological, biochemical and molecular mechanisms of seed priming
17. Study on concept of protective, biological and integrated seed treatments

PRACTICAL SCHEDULE

1. Practicing seed sampling and dividing procedures
2. Determination of seed test weight and assessing sample heterogeneity
3. Conducting physical purity analysis and reporting results
4. Estimation of seed moisture content
5. Conducting seed germination test and seedling evaluation
6. Conducting quick viability test and evaluation
7. Conducting seed vigour tests
8. Biochemical and molecular methods of genetic purity of assessment
9. Conducting seed health tests
10. Visit to seed testing laboratory
11. Practicing water floatation techniques for seed quality enhancement
12. Practicing seed coating and pelleting methods
13. Practicing seed infusion and seed priming techniques
14. Practicing microbial inoculation seed treatments
15. Practicing pre-germination technique
16. Practicing integrated seed treatment in different crops
17. **Final practical examination**

LEARNING OUTCOME

Successful completion of this course by the students will be useful to acquire technical skill on seed quality analysis which leads to the development of human resource on seed quality analysis.

SUGGESTED READING

1. Chakrabarthi, S.K. 2010. Seed Production and Quality Control.Kalyani Publishers. NewDelhi.
2. Renugadevi, J., Srimathi, P., Renganayaki, P. R., and Manonmani, V. 2012.A Hand book of Seed Testing. Agrobios. Jodhpur, Rajasthan.
3. Tridevi, P.C. 2011. Seed Technology and Quality Control.Pointer Publication. Jaipur, Rajasthan.
4. Agrawal, P.K. 1993. Hand book of Seed Testing. Ministry of Agriculture, GOI, New Delhi.
5. Agrawal, R.L. 1997. Seed Technology. Oxford & IBH.
6. Agrawal, P.K. and Dadlani, M. 1992. Techniques in Seed Science and Technology.2nd Ed. South Asian Publications.
7. ISTA. 1999. Seed Science and Technology, 27th supplement.
8. Chalam, G.V. Singh, A and Douglas, J.E. 1967.Seed Testing Manual.ICAR & United States Agency for International Development, New Delhi.
9. Vasudevan, S.N., Doddagowder, S.R., Rakesh C.M. and Patil, S.B. 2013. Seed Testing and Quality Control. Agrotech Publications, Udaipur, Rajasthan.
10. International Seed Testing Association. 2018. Handbook on Seedling Evaluation, 4th Edition, Published by ISTA, Zurichstr, Switzerland.
11. International Seed Testing Association. 2019. International Rules for Seed Testing 2019. Published by ISTA, Zurichstr, Switzerland.
12. Copeland, L. O. and McDonald, M. B. 2001.Principles of Seed Science and Technology.4th Ed. Kluwer Academic publishers, USA.
13. http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/Indian minimum seed Certification standards.pdf.
14. www.kopykitab.com/Seed-Testing-and-Quality-Control-by-Vasudevan-SN.
15. https://www.jstor.org/stable/10.14321/j.ctt7zt51m.
16. https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13.
17. https://www.researchgate.net/publication/269694458_Quality_seed_production_its_testinG_and_certification_standard.
18. https://www.seedtest.org/upload/cms/user/ISTAMethodValidationforSeedTestingV1.01.pdf.
19. https://www.intechopen.com/books/new-challenges-in-seed-biology-basic-and translational-research-driving-seed-technology/recent-advances-in-seed-nhancements.

SUGGESTED WEBSITE

1 http://agritech.tnau.ac.in/seed/Seed_seedtesting.html

2 https://core.ac.uk/download/pdf/85210907.pdf

3 https://www.betterseed.org/resources/seed-testing-accreditation-schemes/

4 http://sbc.ucdavis.edu/About_US/Seed_Biotechnologies/Seed_Enhancement/

5.https://www.seedtest.org/en/international-rules-for-seed-testing-content-1-1083.html

PGR 503 Germplasm Characterization and Evaluation

1+1

WHY THIS COURSE?

Enable students to learn about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses.

AIM OF THE COURSE

To gain knowledge on germplasm characterisation, evaluation and documentation of information. Recording of morphological and agronomic traits, including quality, resilience to biotic and abiotic stresses. Exposure to development of web based tools for systematic description for efficient use of germplasm.

THEORY

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits.

Unit II

Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit III

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation o farmer landraces.

Unit IV

Evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Unit V

High throughput phenotyping systems- imaging& image processing concepts for automated germplasm characterization (phenotyping) – evaluation for nutritional traits, resistance traits - Biochemical and molecular markers for characterization.

PRACTICAL

Field layout and experimental designs; recording field data on germplasm evaluation in different agri-horticultural crops, post-harvest handling; evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing; documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

LECTURE SCHEDULE

1. Understanding genetic diversity in crop plants
2. Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures
3. Evaluation of germplasm for specific traits
4. Measuring diversity using agro-morphological data
5. Statistical procedures to measure population genetic variation, markers and their use in PGR
6. Evaluation of biotic and abiotic stresses
7. Principles and methods for formulating core and mini core collections and their validation
8. **Mid semester examination**
9. Web based tools for management of data
10. Principles and practices of germplasm regeneration and maintenance
11. Breeding systems and mode of reproduction
12. Maintaining sufficiently large populations for effective conservation of farmer
13. Landraces
14. Evaluation and maintenance of wild relatives of crop plants
15. Genetic enhancement, Use of CWRs genetic resources for crop improvement
16. High throughput phenotyping systems- imaging & image processing concepts for automated germplasm characterization (phenotyping)
17. Evaluation for nutritional traits, resistance traits
18. Biochemical and molecular markers for characterization

PRACTICAL SCHEDULE

1. Field layout and experimental designs
2. Recording field data on germplasm evaluation in different agri-horticultural crops: Cereals and millets
3. Recording field data on germplasm evaluation in different agri-horticultural crops: Pulses
4. Recording field data on germplasm evaluation in different agri-horticultural crops: Oilseed crops
5. Recording field data on germplasm evaluation in different agri-horticultural crops: Cotton and sugarcane
6. Recording field data on germplasm evaluation in different agri-horticultural crops: Vegetable crops
7. Recording field data on germplasm evaluation in different agri-horticultural crops: Fruit crops
8. Post-harvest handling
9. Evaluating quality traits
10. Biochemical and phyto-chemical evaluation of crop germplasm
11. Data processing
12. Analysis of diversity

13. Data analysis, viability equations
14. Sampling strategies
15. Data documentation and cataloguing
16. Biochemical analyses of samples
17. **Final practical examination**

LEARNING OUTCOME

Students will know about science of managing genetic resources including principles involved in maintaining genetic integrity during regeneration, germplasm characterization and evaluation.

SUGGESTED READING

1. Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. Plant Genetic Resources Evaluation: Principles and Procedures, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi.
2. Brown, AHD, Clegg, MT, Kahler, AL, Weir, BS (eds.) 1990. Plant Population Genetics, Breeding, and Genetic Resources, Sinauer Associates, USA.
3. Frankel, R and Galun, E 1977. Pollination Mechanisms, Reproduction and Plant Breeding.Monographs on Theoretical and Applied Genetics, Springer-Verlag, Berlin, Heidelberg.
4. Hayward, MD, Bosemak, NO and Romagosa, I. 1993. Plant Breeding: Principles & Practices, Chapman & Hall.
5. Holden, JHN and Williams, JT 1984. Crop genetic resources: conservation and evaluation, IBPGR.
6. Stoskopf, NC 1993. Plant Breeding: Theory & Practice, Westview Press.
7. Puzone, L and Th. Hazekamp 1996. Characterization and Documentation of Genetic Resources Utilizing Multimedia Database. NBPGR, New Delhi.
8. Rana, RS, Sapra, RL, Agrawal, RC and Gambhir, R 1991. Plant Genetic Resources, Documentation and Information Management. NBPGR, New Delhi.
9. Sundeep Kumar, et al 2016.Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases. PloS One Vol 11, pages 0167702.

SUGGESTED WEBSITE

1. https://cropgenebank.sgrp.cgiar.org/index.php/procedures-mainmenu 42/characterization-mainmenu-205
2. https://www.frontiersin.org/articles/10.3389/fpls.2014.00068/full
3. https://www.iaea.org/sites/default/files/21/06/nafa-pbg-manual-molecular-characterizationmutant- germplasm-manual-2015.pdf

PGR 504 Genetic Enhancement for PGR Utilization

1+1

WHY THIS COURSE?

Inculcate theoretical and practical know how to understand and use classical and advanced plant breeding methods for planning and execution of prebreeding programmes so that the PGR is put into effective use for food and agriculture.

AIM OF THE COURSE

To teach theoretical and practical know how on CWRs reproductive behavior, acclimatization and adaptation for utilization in prebreeding programmes using advanced tools.

THEORY

Unit I

Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi exotics, creating and managing variation, basic concepts to set up a successful pre-breeding programme.

Unit II

Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm.

Unit III

Identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

Unit IV

Parental selection for pre-breeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical approaches for gene transfer such as alien addition and substitution, segregating populations and their management in

Unit V

Wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods. Pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre & post-zygotic barriers.

PRACTICAL

Characterization of CWRs by visiting the fields - screening methods for special traits-biotic and abiotic resistance - Screening for nutritional traits - Crossability studies in CWRs of

cereals, legumes, oilseeds, vegetables. Assessment of pre and post-zygotic barriers in wide hybridization crosses - Pollen storage studies - special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, etc.

LECTURE SCHEDULE

1. Concepts of gene pools Introduction, potential of pre-breeding
2. Role of crop wild relatives, semi exotics, creating and managing variation
3. Basic concepts to set up a successful pre-breeding programme
4. Understanding crop adaptation, handling and maintenance of CWRs
5. Synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments
6. Role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable traits in natural populations
7. Screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits
8. **Mid semester examination**
9. Genetic analysis to understand the inheritance of novel traits
10. Parental selection for pre-breeding, search for superior genotypes
11. Breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization
12. Incongruity and its management, modern tools for incongruity management
13. Cytogenetical approaches for gene transfer such as alien addition and substitution
14. Segregating populations and their management in wide crosses
15. Purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods
16. Pollen physiology and storage, pollen storage methods to facilitate wide hybridization
17. Pre & post-zygotic barriers

PRACTICAL SCHEDULE

1. Characterization of CWRs by visiting the fields- rice
2. Characterization of CWRs by visiting the fields- pulses
3. Characterization of CWRs by visiting the fields- millets & oilseeds
4. Characterization of CWRs by visiting the fields- cotton
5. Characterization of CWRs by visiting the fields- Forage crops
6. Screening methods for special traits-biotic resistance
7. Screening methods for special traits-abiotic resistance
8. Screening for nutritional traits
9. Crossability studies in CWRs of cereals,
10. Crossability studies in CWRs of legumes
11. Crossability studies in CWRs of oilseeds
12. Crossability studies in CWRs of vegetables
13. Assessment of pre-zygotic barriers in wide hybridization crosses

14. Assessment of post-zygotic barriers in wide hybridization crosses
15. Pollen storage studies
16. Special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, etc
17. **Final practical examination**

LEARNING OUTCOME

Students would be conversant with handling of unadapted germplasm, screening methods for special traits-biotic and abiotic resistance, nutritional traits, characterization of CWR, breeding, etc.

SUGGESTED READING

1. Sharma S, Upadhyaya HD, Varshney RK, et al. 2013.Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. Front. Plant Sci.4:309.
2. Bisht et al. 2004. Broadening the genetic base of sesame (Sesamum indicum L.) through genetic enhancement. Plant Genetic Resources 2 (3) : 143-151.
3. Duvick, DN. 1990. Genetic enhancement and plant breeding. p. 90-96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.
4. Ramanatha Rao, V, Brown AHD, Jackson M. 2001. Managing Plant Genetic Diversity.CABI Publication.
5. Goodman, RM. 2004. Encyclopedia of plant and crop science. Marcel Dekker Inc., Switzerland.
6. Kimber, G and Feldman, M. 1987. Wild Wheat: An introduction. Special report 353, College of Agriculture, University of Missouri-Columbia.

SUGGESTED WEBSITE

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7907825/
2. https://www.pnas.org/content/96/11/5937
3. https://academic.oup.com/bfg/article/17/3/198/4982565

PGR 507 PGR Exchange and Quarantine 2+1

WHY THIS COURSE?

In view of updated rules and regulations for access of germplasm and its safe movement following international phytosanitary measures, these issues need to be taught in detail.

AIM OF THE COURSE

Impart knowledge on safe exchange of germplasm nationally and internationally Along with the quarantine related issues which are either legislative or technical.

THEORY

Unit I

History, principles, objectives and importance of plant introduction, pre-requisite and conventions for exchange of PGR, national and international legislations and policies. Principles, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India

Unit II

Pest risk analysis, pest and pathogen information database; quarantine in relation to integrated pest management, symptoms of pest damage, economic significance of seed-borne pests (insects, mites, nematodes, fungi, bacteria, viruses, phytoplasma, viroids, weeds, etc.), detection and identification of pests including use of recent techniques like ELISA, PCR, etc.

Unit III

Salvaging techniques for infested/ infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities, domestic quarantine; seed certification; international linkages in plant quarantine, weaknesses and future thrust.

Unit IV

Symptoms of pest damage, pests of quarantine significance forIndia, sampling of bulk material for quarantine, Plant Quarantine/ biosecurity system in other countries, case histories of alien invasive species.

UNIT V

Genetically Modified Organisms (GMOs) or Genetically Engineered Plants (GEPs),Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

PRACTICAL

Inventory of IQ/ EQ samples; Joint inspection for pest detection; Detection of pests of quarantine significance (Conventional, Electron microscopy, ELISA and molecular techniques); Primer designing; Pest risk analyses, quarantine in relation to integrated pest management; salvaging of infested/ infected germplasm; Seed treatment and other prophylactic treatments and facilities; domestic quarantine; seed-health certification.

LECTURE SCHEDULE

1. History, principles, objectives and importance of plant introduction.
2. Pre-requisite and conventions for exchange of PGR,
3. National and international legislations and policies.
4. Principles, objectives and relevance of plant quarantine.
5. Regulations and plant quarantine set up in India.
6. Pest risk analysis,

7. Pest and pathogen information database;
8. Quarantine in relation to integrated pest management,
9. Symptoms of pest damage,
10. Economic significance of seed-borne insects and mites pests.
11. Economic significance of seed-borne nematode pests.
12. Economic significance of seed-borne fungus and bacterial diseases.
13. Economic significance of seed-borne viral diseases.
14. Economic significance of seed-borne phytoplasma and viroid diseases ,
15. Economic significance of seed-borne weeds
16. Detection and identification of pests and Use of recent techniques like ELISA, PCR.
17. **Mid-semester Examination**
18. Salvaging techniques for infested/ infected germplasm,
19. Post-entry quarantine operation,
20. Seed treatment and other prophylactic treatments and facilities,
21. Domestic quarantine;
22. Seed certification and quarantine
23. International linkages in plant quarantine, weaknesses and future thrust.
24. Symptoms of pest damage,
25. Pests of quarantine significance for India.
26. Sampling of bulk material for quarantine,
27. Plant Quarantine/ biosecurity system in other countries,
28. Case histories of alien invasive species.
29. Genetically Modified Organisms (GMOs)
30. Genetically Engineered Plants (GEPs).
31. Concepts of biosafety,
32. Risk analysis and consequences of spread of GE crops on the environment;
33. Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs,
34. Indian regulatory system for biosafety.

PRACTICAL SCHEDULE

1. Inventory of IQ/ EQ samples;
2. Joint inspection for pest detection;
3. Conventional detection of pests of quarantine significance.
4. Electron microscopy detection of pests of quarantine significance.
5. ELISA detection of pests of quarantine significance.
6. Molecular detection of pests of quarantine significance.
7. Primer designing.
8. Pest risk analyses.
9. Disease risk analysis
10. Quarantine in relation to integrated pest management.
11. Quarantine in relation to integrated disease management
12. Salvaging of infested/ infected germplasm.

13. Seed treatment and other prophylactic treatments and facilities.
14. Domestic quarantine
15. Sampling of bulk material for quarantine
16. Seed-health certification.
17. **Final Practical Examination**

LEARNING OUTCOME

Knowledge gain on current national and international regulations related to germplasm exchange and plant quarantine, detection techniques for pests, salvaging methods, sampling techniques, biosafety of transgenics, etc.

SUGGESTED READING

1. Albrechsten SE. 2006. *Testing methods for seed-transmitted viruses: principles and protocols*. UK: CAB International, Wallingford. 268 p.
2. Bhalla S, Chalam VC, Tyagi V, Lal A, Agarwal PC and Bisht IS. 2014. Teaching Manual on Germplasm Exchange and Plant Quarantine. ICAR-NBPGR, New Delhi, India p. 340+viii.
3. Bhalla S, Chalam VC, Lal A, and Khetarpal RK. 2009. *Practical Manual on Plant Quarantine*. National Bureau of Plant Genetic Resources, New Delhi, India.204p+viii.
4. Bhalla S, Chalam VC, Singh B, Gupta K and Dubey SC. 2018. Biosecuring Plant Genetic Resources in India: Role of Plant Quarantine. ICAR-NBPGR, New Delhi vi+216 p.
5. Chalam VC, Dubey SC, Murali Krishna C, Bhalla S and Singh K (eds.). 2018. *Transboundary Movement of Living Modified Organisms: Strengthening Capacities of Enforcement Agencies*. ICAR-National Bureau of Plant Genetic Resources and Ministry of Environment, Forest and Climate Change, New Delhi, India.vi+159 p. ISBN 978-81-937111-2-5
6. Gupta K and Dubey SC. 2017. 'Biosecurity policies influencing international exchange of PGR.'*Indian Journal of Plant Genetics Resources* **30**: 258-266.
7. Khetarpal RK, Lal A, Varaprasad KS, Agarwal PC, Bhalla S, Chalam VC and Gupta K. 2006. Quarantine for Safe Exchange of Plant Genetic Resources. In: *Hundred Years of Plant Genetic Resources Management in India* (eds. AK Singh, Kalyani Srinivasan, Sanjeev Saxena and BS Dhillon), National Bureau of Plant Genetic Resources, New Delhi, pp 108-139.
8. Richardson MJ. 1990. An Annotated list of seed-borne diseases (Fourth Edition). International Seed Testing Association, P.O. Box 412.CH 8046 Zurich, Switzerland.