

PONDICHERRY UNIVERSITY



7th PG BOARD OF STUDIES IN AGRICULTURAL SCIENCES

DOCTORAL DEGREE PROGRAMME
REGULATIONS AND CURRICULUM
(Effective from 2023 - 24)

**PANDIT JAWAHARLAL NEHRU COLLEGE OF
AGRICULTURE
AND RESEARCH INSTITUTE (PAJANCOA&RI)
(A Government of Puducherry Institution)
KARAIKAL – 609 603**

**PONDICHERRY UNIVERSITY
PUDUCHERRY – 605 014**



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REGULATIONS

PONDICHERRY UNIVERSITY

PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND
RESEARCH INSTITUTE, KARAIKAL

DOCTORAL DEGREE PROGRAMME SEMESTER SYSTEM - RULES AND REGULATIONS 2023

01. SYSTEM OF EDUCATION

1.1 The rules and regulations provided herein shall govern Doctoral degree programme offered by Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA&RI), Karaikal under Pondicherry University.

1.2 The duration of Doctoral programme is three academic years (6 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. The third year of study shall be the fifth and sixth semesters.

02. COMMENCEMENT

These regulations shall come into force from the academic year 2023-24.

03. 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 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 fulfilment of the postgraduate degree programme.
- 3.5** 'Curricula and syllabi' refer to list of approved courses for Ph.D programmes wherein each course is identified with a 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** '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 1+0 course (1 credit) means 1 hour theory per week
- 3.11** '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.
- 3.12** 'Grade Point' means the total marks in percentage obtained in a course divided by 10 and rounded to two decimals.
- 3.13** 'Credit Point' means the grade point multiplied by the credit load of the course.
- 3.14** '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.
- 3.15** 'Arrear examination' is an examination written for the failed course by a student without undergoing regular classes in that course.
- 3.16** 'Transcript Card' is the consolidated report of academic performance of a student issued by the University on completion of the curriculum fulfilment. The format of Transcript Card is furnished in *Annexure-1*.

04. DOCTORAL PROGRAMMES

The Doctoral programme offered in the College is as follows:

4.1 DOCTOR OF PHILOSOPHY [Ph.D.]

Ph.D. Agricultural Economics
Ph.D. Agronomy
Ph.D. Genetics and Plant Breeding
Ph.D. Soil Science
Ph.D. Vegetable Science

05. ADMISSION

5.1. Eligibility for admission:

- i. Candidates seeking admission to Doctoral degree programme should have a two year Master's degree from State Agricultural Universities (SAU) or from other institutes accredited by NAEAB (ICAR) alone are eligible to apply for the doctoral program.

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 Doctoral degree programme in this Institute.

iii. Prescribed minimum qualification from a recognized University for admission to Doctoral degree programme:

Requirement for Doctoral Degree

Sl. No.	Degree	Requirement for Doctoral degree programs
1.	Ph.D. Agricultural Economics	M.Sc. (Agri.) Agricultural Economics
2.	Ph.D. Agronomy	M.Sc. (Agri.) Agronomy
3.	Ph.D. Genetics & Plant Breeding	M.Sc. (Agri.) Plant Breeding and Genetics / M.Sc. (Agri.) Genetics and Plant Breeding / M.Sc. (Agri.) Plant Genetic Resources
4.	Ph.D. Soil Science	M.Sc. (Agri.) Soil Science / M.Sc.(Agri.) Soil Science and Agricultural Chemistry
5.	Ph.D. Vegetable Science	M.Sc. Vegetable Science/ M.Sc. (Hort.) Vegetable Science

5.2. 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.

5.3. Method of selection:

i. The admission to the Doctoral Programme is based on the marks / rank obtained in ICAR's All India Entrance Examination (AIEEA) / ICAR's All India Competitive Examination (AICA-SRF (Ph.D.) /CUET.

ii. Number of seats in each Ph.D. degree programme shall be decided as per availability of recognised Ph.D. guide.

iii. Seats are reserved for candidates belonging to SC/ST, OBC as per the norms of Govt of Puducherry.

5.4. Admission procedure:

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

ii. 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.

06. LANGUAGE REQUIREMENT

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

07. RESIDENTIAL REQUIREMENT

- i. The minimum and maximum duration of residential requirement for Ph.D. Programmes shall be as follows

Duration of Residential Requirement	
Minimum	Maximum
3 Academic Years (6 semesters)	7 Academic Years (14 Semesters)

Student may be allowed to discontinue temporarily only after completion of coursework

- ii. In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled.

08. 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.

09. DISCONTINUANCE AND READMISSION

As per University Regulations.

10. ADVISORY COMMITTEE

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

10.2. Chairperson/Guide:

- i. The approved guides by the University only can be the guide for the students.
- ii. Every student shall have a Chairperson of the Advisory Committee who will be from his/her major field of studies.
- iii. The appointment of chairperson shall be made by the Head of the Department.
- iv. The Head of the department will allot the Doctoral students among the recognized guides.
- v. A teacher should have a **minimum of three years** of service before retirement for allotment of Doctoral students.
- vi. At any given time, a PG teacher shall not be a Chairperson of Advisory Committee (including Master's and Ph.D. programmes) for more than five students.

10.3. Chairperson/ Co-guide/ Member from other collaborating University/ Institute/ Organization:

- i. In case the Chairperson has less than 3 years of service he can be allowed to act as Co-guide / Member of the Advisory Committee.
- ii. The University / Institute may enter into Memorandum of Understanding (MOU) with other Universities / Institutions / Organizations for conducting research. However, to

include faculty of Pondicherry University to act as Co-guide / Member of the Advisory Committee Memorandum is not required.

- iii. 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 of a chairperson and three members. One member will be from the concerned department and other members from the related field of thesis research from other departments / discipline of the Post-graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of two years or more may be included in the Advisory Committee as member.
- ii. External experts may be included as member/co-guide in the advisory committee based on the need and expertise of the member, without any financial commitment to the College so as to improve the quality of the thesis. The external expert member proposed should meet the minimum qualification required and the proposal is to be approved by the Dean.

10.5. Formation of advisory committee:

- i. For Doctoral Programme the advisory Committee Chairperson and members will be in the cadre of Professors, Associate Professor and Assistant Professors.
- ii. A proposal for the formation of the advisory committee (**Form 1**) of the student, shall be forwarded by the Head 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.

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

- i. Conducting qualifying and 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 Doctoral 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 Chairperson of advisory committee, respective Heads of Departments should act as Co-chairperson with prior permission of Dean.

10.8. Duties and responsibilities of the advisory committee:

- i. Drawing the student's academic plan for Doctoral 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 Doctoral course work (**Form 2**) drawn up by advisory committee shall be sent to the Dean before 55th working day 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 Doctoral student should complete a minimum of 100 credits as detailed below for award of the degree.

Credit Requirements

Details	Credits
i) Course Work	
Major Courses	12
Minor Courses	06
Supporting Courses	05
Seminar-2 nos. each 0+1 credit	02
ii) Thesis Research	75
Total Credits	100

13.2. Maximum credit load: A Doctoral student can register a maximum of **22 credits per semester** including seminar and research. However, research credits registered per semester shall not exceed **20 credits**.

13.3. Comprehensive qualifying examination and thesis: A Doctoral 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 Doctoral programme.
- ii. The extra credits registered will be accounted for calculation of OGPA.

14. ATTENDANCE REQUIREMENTS

14.1. A minimum of 80 per cent attendance separately in theory and practical of the concerned course is a must. However, the attendance may be condoned up to 10%, under extra-ordinary situation, by the Dean based on the genuineness of the case and upon the recommendation of the Advisory Committee and Head of the Department, 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.

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.

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.
- iv. For calculating 80 percent attendance the number of instructional days may be calculated only from the date of joining of the student for first year first semester only.
- v. The students failing to attend the classes / examinations on non-official ground will be treated as absent.
- vi. 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. In each course, examinations will be conducted for 100 marks as detailed below.

Examination	Courses with theory & practical	Courses with only theory
Term Paper	20	20
Final Theory Examination	60	80
Final Practical Examination	20	-
TOTAL	100	100

15.2. Final Theory Examination:

- i. An examination schedule prepared by the Dean 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 three hours.
- iii. The final theory examinations shall be **conducted and evaluated internally** by the course teacher.
- iv. Re-valuation/Re-totalling is not allowed for theory examinations.
- v. No re-examinations shall be allowed in the events of students' strike, boycott, walkouts, and medical grounds or what-so-ever may be the reason.

15.3. Postponement of Final Theory Examination:

Whenever the Government declares holidays on the dates of final examinations, the examinations that fall on the dates shall be postponed to the dates after the last examination as per the original examination schedule.

15.4. Final Practical Examination:

- i. The Head of the Department will announce the schedule of final practical examinations.
- ii. The final practical examinations shall be conducted after the completion of minimum of 96 working days.
- iii. Submission of bonafide practical records and term paper in complete form and certified by the Course Teacher is a pre-requisite for appearing in a practical examination failing which 'F' grade will be awarded.
- iv. The final practical examination of the course shall be conducted and evaluated by the course teacher.
- v. The duration of final practical examination shall be two and half hours.
- vi. The practical examination marks should be communicated to the Dean within ten days after the conduct of respective final practical examinations.

15.5. Arrear examination:

- i. Arrear examination is permitted for the final theory and final practical examination.
- ii. The students are permitted to write the arrear examinations along with the regular semester examination
- iii. The prescribed arrear examination fee should be paid on or before the specified date.
- iv. A student is permitted to write the final theory and practical examinations (Term paper marks shall be retained as such) only two times during 3 years duration excluding the regular final examination.
- v. 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 juniors as and when the course(s) are

offered with the permission of the University on payment of the prescribed Re-registration fee.

- vi. 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.

15.6. Late comer in Examinations:

- i. The students who are late by 30 minutes shall not be allowed to enter the examination hall.
- ii. Similarly, no student will be allowed to leave the examination hall within 30 minutes of the commencement of the examination.

15.7. All theory examinations shall be conducted in the Examination hall of the College. The student should necessarily come to the examination hall(s) with Identity card and hall tickets and produce the same to the examiner(s)/invigilator(s), failing which the student shall not be allowed to write the examinations.

15.8. Hall tickets:

- i. The students shall be issued with hall tickets for writing their final theory/practical examinations.
- ii. The PG coordinator of the concerned department shall prepare the hall tickets, get the approval of the Head of the Department and issue to the students.
- iii. In case of loss of hall tickets by the students, duplicate hall ticket shall be issued on payment of prescribed fine.
- iv. The students who have lost/missed their hall tickets shall apply to the Head of the Department for getting a duplicate hall ticket.

15.9. Evaluation of Course Work:

- 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. 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 % Attendance)
 - F - FAILED
 - RR - RE-REGISTRATION
 - RE - RE- EXAMINATION
 - EE - INCOMPLETE FOR REASONS OTHER THAN ATTENDANCE

15.10. Question paper pattern for theory examinations:

15.10.1. The question paper pattern for final theory examinations are indicated below:

Part	Type of question	Number of question	Number of questions to be answered	Mark per question	Total marks
Courses with theory and practical (1+1 or 2+1 courses) (60 Marks & 3 hours duration)					
A	Definitions/Concepts	12	10	1.0	10
B	Paragraph answers	7	5	4.0	20
C	Essay type answers (EITHER OR type) - One main question from each unit shall have one choice	5	5	6.0	30
	TOTAL				60
Courses with only theory (1+0 or 2+0 courses) Final Theory Examination (80 Marks & 3.0 hours duration)					
A	Definitions/Concepts	18	15	1.0	15
B	Paragraph answers	7	5	5.0	25
C	Essay type answers (EITHER OR type) - One main question from each unit shall have one choice.	5	5	8.0	40
	TOTAL				80

15.10.2. **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
Practical Field work / Lab Work / Written exam	20
Total	20

For conducting practical examinations, the type and number of questions can be decided by the course teacher.

15.11. 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.

15.12. Return of valued answer papers:

- i. The valued answer papers of final theory and practical examination 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 six months and then disposed off.
- iii. The same is applicable to arrear examination also.

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 Ph.D. Department shall send a panel of three examiners for conducting the comprehensive qualifying examination (**Form 4**).
- ii. The Controller of Examinations, shall nominate the external member from the panel for conducting qualifying examination of all the students of the department. However, the University can draw its own panel of examiners.
- iii. The panel of examiners for qualifying examinations shall be given by the Head of the Department 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 doctoral 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 and evaluated 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. 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 Chairperson 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 Doctoral 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.

16.6. Communication of results of qualifying examination:

- i. The Chairperson of the advisory committee shall act as Chairperson for the examination committee.
- ii. The Chairperson 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).

17. CREDIT SEMINAR

17.1. Seminar is compulsory for all the Doctoral students and each Doctoral student should register and present two seminars with 0+1 credit.

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

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 research.
- ii. The seminar topics are to be assigned to the students by the Chairperson 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% attendance in the semester in the presence of the Advisory committee, staff and Doctoral students of the concerned department.
- ii. The circular on the presentation of the seminars by the Doctoral 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 Chairperson 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 of Marks

Sl. No.	Description	Marks
1.	Synopsis of the Seminar	10.00
2.	Presentation	
	a) Introduction	05.00
	b) Style Clarity	10.00
	c) Sequence and Organization	05.00
	d) Topic Coverage	20.00
	e) Effective use of Audio Visual Aids	05.00
	f) Time Management	05.00
	g) Response to Question during discussion	10.00
3.	Report	30.00
	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.

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 area and 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 Doctoral programme should be of such a nature as to indicate a student's potentiality 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 Chairperson of the Advisory Committee shall accompany the thesis.

18.2. Research Colloquium:

- i. The research proposal has to be presented by the student in a colloquium organized by the Head of the department/Dean to get the opinion/ suggestions of the scientists of the concerned/other departments for improving it and approved by the Dean
- 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- Part A**). 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 students to monitor whether the student has 80% of attendance in research.
- iii. After completion of 80% attendance for research and on or before the last day of the semester, the advisory committee should evaluate the progress of research work as per the approved programme and monitoring register (**Proforma 6**) 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 subsequent 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.
 - 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' shall be awarded. The student has to

reregister the same block of research credits for which 'E' grade was awarded in the subsequent 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 cannot 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 cannot 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

19.1.

- i. The research credits registered in the last semester of Doctoral 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-4**.
- ii. If a Doctoral student has completed the thesis before the closure of the final semester, the Chairperson 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. During submission of thesis for external evaluation, it is mandatory to enclose certificate for plagiarism check under reference management (**Proforma 15**) as per UGC norms.
- iv. Copy of the thesis to be sent for evaluation should be submitted in paper pack.

v. 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).

19.2. Grace period:

- i. Students can avail a grace period up to three months for submission of thesis after the closure of final semester by paying prescribed fine.
- 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(s) 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 Department can sanction the grace period based on the recommendation of advisory committee and a copy of the permission letter along with the receipt for payment of fine should accompany the thesis while submission.

19.3. Re-registration and submission of thesis: The minimum of 80% attendance requirement for submitting the thesis after re-registration need not be insisted for those students who have fulfilled the minimum academic and residential requirement i.e. 3 years (6 semesters) and completed the minimum credit requirements with 80% attendance.

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

- **It is encouraged to publish minimum two research articles from the Doctoral thesis work.**
- Publication of two research articles should be made in UGC listed journals. The chairperson can also encourage the scholars to publish in high impact factor journals.

20. EVALUATION OF THESIS

20.1. The thesis submitted in partial fulfilment of a Doctoral degree shall be evaluated by two external examiners nominated by the Controller of Examinations, upon recommendation of the Dean, from a panel of five names of specialists (**Form 6**) in the particular field in India.

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

20.3. An oral examination (public defence) will be conducted by the Advisory Committee after the thesis is recommended by the external examiners besides the student should have carried out the corrections/suggestions made by the external examiners (**Form 8**). Public defence for doctoral students shall be conducted by the Chairperson of the advisory committee with the addition of one of the External Examiners nominated by the University on the working days in the presence of a **Proctor** appointed by the Dean to oversee the entire proceedings as a part of internal quality monitoring. The Heads of the Department shall nominate one Professor as a 'Proctor' from any Departments other than his department and it shall be approved by the Dean. In addition, the proctor has to sign in the public defence report. The Chairperson shall send the recommendations of the advisory committee along

with necessary certificate/documents in duplicate to the Dean. The thesis shall be finally accepted for the award only after the student satisfactorily completes a public defence.

20.4. The aims of the Ph.D thesis defence are to evaluate the candidate's academic competence, performance and his/her ability to interpret and discuss the undertaken research independently. The candidate is obliged to give a short lecture supporting his/her PhD thesis, publications and future research outlines. The final evaluation determines the candidate's academic results and conclusions i.e how clearly does he/she achieved the research objectives, solved the problems and obtained solutions; how logically the results are interpreted and further research possibilities outlined. Questions posed and clarification provided by the candidate during the defence gives an impression about the candidate's ability in academic debate.

20.5. The Chairperson shall send the recommendations of the advisory committee (**Form 7**) along with necessary certificate/documents in duplicate to the Dean. On the unanimous recommendation of the committee and with the approval of the University, the degree shall be awarded to the candidate.

20.6. The result declaration proposal will be sent by the Dean to the Controller of Examinations.

20.7. i. In case of difference of opinion on the acceptability of thesis for the award, the Controller of Examination may on the special recommendation of the advisory committee, refer the thesis for scrutiny and independent judgment to a third external expert chosen by him.

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

iii. If however, the opinion is still not uniform the degree shall not be awarded.

iv. In the above case, the advisory committee shall send their recommendation to the Dean within one month from the date of receipt of the thesis for scrutiny.

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 Dean.

ii. If the revision is recommended for repeating lab experiments, field trial etc., resubmission must be after a minimum 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. (**Form 8**)

22. FAILURE TO APPEAR FOR PUBLIC DEFENCE/NON-SUBMISSION OF THESIS AFTER PUBLIC DEFENCE

22.1. If a candidate fails to appear for public defence on the date fixed by the Chairperson the following are the time-frame and penalty.

The defence must be completed within **seven years from the date of** first registration for the degree program. An amount of penalty/ fine of Rs.5,000/-shall be levied to the candidate.

22.2. After successful completion of public defence if a student fails to submit the corrected version of the thesis within 15 days he/she shall be levied a fine of Rs. 5,000/- at the time of sending the proposal for result declaration.

23. RESULT NOTIFICATION

23.1. After the completion of each semester, the student shall be given the Report Card by the University.

24. MALPRACTICES IN EXAMINATION AND MISCONDUCT OF STUDENTS

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

24.2. The invigilator or the course teacher concerned shall report each case of unfair means with full details of evidence and written explanation of the student concerned to the Dean immediately.

24.3. The Dean shall take appropriate action on receipt of the report and the penalty may be as indicated below.

- i. Students found using unfair means during the final theory/practical examination will be deemed to have failed in all the courses in that semester and also debarred from the college for the next semester.
- ii. For using unfair means of a serious nature (which will be decided by committee nominated by the Dean) warranting higher penalties than those indicated in clauses **24.3 (i)** and **24.3 (ii)** the student may be debarred from the College for a period of two semesters or more or expelled permanently after obtaining the orders of the University. In such cases, the students concerned shall not be allowed to sit for the remaining examinations in the concerned course or other courses.
- iii. Details of each case together with all material evidence and recommendations of the Dean shall be communicated forthwith to the Registrar of the university. The Dean shall issue necessary orders and report each case falling under clauses **24.3 (i)**, **24.3 (ii)** and **24.3 (iii)** to the Registrar immediately.

24.4. Ragging rules: Students found involved in ragging or in any other misconduct, or on a report received from the affected student(s), the Dean shall immediately expel the concerned student(s) against whom the report is received from Hostel/College, for the current semester and the Dean shall further constitute a committee to probe and conduct enquiry into the matter and based on the report from the committee, shall pass the final orders on merit of the case within three working days. As per the order of the Supreme Court of India, the punishment for ragging may take the shape of (a) Withholding scholarships or other benefits (b) debarring from representation in events (c) withholding results (d) suspension or expulsion from hostel or mess and the like.

24.5. 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.

25. RECOGNITION OF DOCTORAL TEACHERS

25.1. The Dean normally recognizes teachers for offering courses to the students of Doctoral programme based on the request of teachers and the recommendation of Head of the department.

25.2. The recognized Ph.D. teachers shall offer courses to Doctoral 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.

25.3. **Teachers for Doctoral programme:** The following faculty shall be recognized as PG teachers for Doctoral programme

- i. Professors
- ii. Associate Professors
- iii. Assistant Professors: Persons having a Doctoral degree with five years of active experience in the concerned field.

25.4. 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**.

25.5. 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.

26. APPROVAL OF FINAL RESULTS, AWARD OF DEGREE AND ISSUE OF PROVISIONAL CERTIFICATES AND TRANSCRIPTS

26.1. Award of Degree:

- i. The Degree will be awarded during Annual Convocation conducted by the University to candidates who have satisfactorily completed all the graduation requirements.
- ii. The University shall issue a Provisional Degree Certificate to a candidate after having passed all provisional examinations.
- iii. Date of completion of degree programme shall be the date of final viva-voce examination/ public defence.

26.2. 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.

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

26.4. 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.

26.5. The Transfer Certificate and Conduct Certificate shall be issued by the Dean.

26.6. The Vice-Chancellor is empowered to withhold or cancel the Degree awarded when a mistake wilfully committed by the student is detected at a later date regarding the registration, OGPA and other requirements for successful completion of the degree programme.

26.7. Amending or Cancelling the Result: If it is established that the result of a candidate has been vitiated by malpractice, fraud or other improper conduct and that he/she has been a party to or connived at malpractice or improper conduct of another student, the Vice-Chancellor shall have the powers at any time to amend the results of such a candidate and to make such declaration as the Vice-Chancellor may deem necessary on that behalf including return of prize, scholarship money and debarring the candidate from the University for such periods as may be specified and to cancel the results of the candidate in such manner as the Vice-Chancellor may decide.

27. REMOVAL OF DIFFICULTIES:

27.1. If any difficulty arises in giving effect to the Provisions of these regulations, the Registrar/Dean may issue necessary orders which appear to him to be necessary or expedient for removing the difficulty.

27.2. Every order issued by the Registrar/Dean under this provision shall be laid before the Academic Council of the University immediately after the issuance.

27.3. Notwithstanding anything contained in the rules and regulations, the Board of Studies or Academic Council shall make changes whenever necessary.

**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.	Re-registration fee with juniors	1000
3.	Duplicate hall ticket fee	200
4.	Fee for Transfer Certificate and Conduct Certificate	200
5.	Re-examination fee for comprehensive Qualifying Exam	5000
6.	Fee for availing grace period for submission of thesis a) Up to one month b) Up to three months	1000 2500
7.	Penalty for failure to appear for public defence	5000
8.	Penalty for late submission of thesis after public defence	5000
9.	Examination fee (per course) *	
10.	Improvement/ Re-examination fee (per course) *	
11.	Fee for Provisional Degree Certificate *	
12.	Fee for Transcript Card *	
13.	Fee for Degree Certificate *	
14.	Fee for Migration Certificate *	

* As fixed by the University from time to time

28. REGULATIONS GOVERNED BY PAJANCOA & RI

28.1. FEE STRUCTURE

- i) 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.
- ii) In the case of new admissions, the fees for the first semester should be paid at the time of admission.
- iii) For the remaining semesters, the fees should be paid on the date of registration of the semester.
- iv) Candidates who discontinue after admission are not eligible for refund of fees except caution money deposit.
- v) In case of a student who re-registers with junior batch, he/she has to pay the semester fees applicable to the junior batch in which he/she registers, besides the re-registration fee.

28.2. REGISTRATION

- i) All newly admitted candidates should register during the first semester of the programme. A candidate admitted to the Doctoral 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.

- ii) **In ABSENTIA** registration will not be permitted on any circumstances.
- iii) The Head of the Department and the PG coordinator shall help the student in selecting the courses for registration.
- iv) Admitted candidates shall register with the respective Department at the beginning of each semester and this should be completed within two working days.

28.2.1. Late registration:

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

28.2.2. 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

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

28.3. QUALIFYING EXAMINATION

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

28.4. MERIT SCHOLARSHIP/RESEARCH ASSISTANTSHIP

- i) PAJANCOA & RI fellowship shall be awarded to all the students who are admitted into the Ph.D programme based on allotment of Government fund. The students should be a resident of PAJANCOA & RI hostels. The award of fellowship is governed by the approved fellowship rules.
- ii) The Dean shall call for applications and sanction the scholarship every year.
- iii) The students availing any scholarship/fellowship are permitted to switch over to other fellowship/scholarship only one time during the course of study.

28.5. Student SRF:

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

28.6. GUIDELINES FOR HEADS OF THE DEPARTMENTS IN MONITORING PROGRESS OF DOCTORAL STUDENTS

28.6.1. Student records: The "Individual student" file (clip file) containing all the academic records of the student concerned with student's 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:

28.6.2. 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.	Mark lists after completing examinations	Within 10 days from the date of conduct of examinations

28.6.3. 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.

28.6.4. The schedule for the important records to be sent to the Dean is furnished below and it 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)	
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)	The next day of the examination
6.	Panel of external examiners for	Three months before the probable date of

	thesis evaluation (Form 6)	submission of thesis
7.	Final viva-voce result (Form 7)	The next day of the examination
8.	Certificate for having carried out the suggestions of the external examiner and advisory committee (Form 8)	After receiving the evaluation report from the external examiner.

28.6.5. The Heads of the Departments should monitor the progress of the Doctoral 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

PROFORMA FOR FORMATION OF ADVISORY COMMITTEE

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

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

S.No.	Advisory committee	Name, designation and department	Date of Retirement	Signature
1.	Chairperson :			
2.	Co-Guide (If any) :			
3.	Member	1.		
		2.		
		3.		
4.	Additional member :			
5.	Reasons 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, KARAİKAL – 609 603**

PROFORMA FOR CHANGE IN ADVISORY COMMITTEE

(To be sent in triplicate)

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

	Name and designation	Date of retirement	Signature
a. Existing Chairperson/ Co-Guide/ member			
b. Proposed Chairperson/ Co-Guide member			

6. Reasons for change :

Signature of the student

Chairperson of the Advisory Committee

PG Coordinator

Head of the Department

DEAN

Form – 2

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

PROFORMA FOR PLAN OF COURSE WORK

(To be sent in triplicate before 55th working day during the first semester)

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

S. No.	Course No	Course Title	Credit Hour
		Major courses	
		Minor courses	
		Supporting 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
Chairperson		
Co-Guide (If any)		
Members	1.	
	2.	
	3.	

DEAN

Form – 3

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

PROFORMA FOR 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. Reg. 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
Chairperson		
Co-Guide(If any)		
Members	1.	
	2.	
	3.	

DEAN

Form – 3a

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

PROFORMA FOR CHANGE IN PROGRAMME OF RESEARCH

(To be sent in triplicate)

1. Name :
2. Reg. 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
Chairperson		
Co-Guide (If any)		
Members	1.	
	2.	
	3.	

DEAN

Form – 4

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

PROFORMA FOR 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 Ph.D. students appearing for qualifying examination :

Sl. No.	Name	I.D. 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

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

PROFORMA FOR COMMUNICATION OF RESULTS OF
QUALIFYING EXAMINATION

(To be sent in triplicate)

1. Name of the student:
2. Reg. 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
Chairperson		
Co-Guide (If any)		
Members	1.	
	2.	
	3.	
External Examiner		

Signature of Chairperson
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

PROFORMA FOR PROPOSAL OF EXTERNAL EXAMINERS FOR THESIS EVALUATION

(To be sent in duplicate in Confidential cover)

1. Name of the student :
2. Reg. No. :
3. Degree :
4. Subject :
5. Thesis title :

6. Name of the Chairperson :
7. Panel of external examiners* :

Sl. No.	Name and Designation	Address with Contact No. and Email	Area of specialization
1.			
2.			
3.			
4.			
5.			

*Five external examiners should be given

8. Remarks :

**Signature of the Chairperson
of the advisory committee**

DEAN

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

PROFORMA FOR SENDING THE RESULT OF FINAL THESIS VIVA-VOCE EXAMINATION

(To be sent in duplicate)

1. Name of the student :
 2. Reg. 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
1.	RECOMMENDED /RECOMMENDED FOR REVISION /NOT RECOMMENDED
2.	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.	Chairperson/Co-opted Chairperson*		
2.	Co-Guide		
3.	Member 1.		
	2.		
	3.		
4.	Additional member		
5.	External examiner		

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

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

Head of the Department

**Chairperson of the Examining committee/
 Advisory committee with designation**

Form – 8

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

**Certificate for having carried out the suggestions of the External Examiner and Advisory
committee**

(To be enclosed along with report of the public defense)

Certified that Thiru/Selvi/Tmt. _____

I.D. No. _____ has carried out all the corrections and suggestions as pointed
out by the external examiners (s) and the advisory committee and has submitted _____
copies of his/her Ph.D. thesis in hard bound cover and CD's.

**Signature of the Chairperson with
Designation**

Signature of the PG Coordinator

**Signature of the Head of the
Department**

Approved By

DEAN

SEAL OF THE
UNIVERSITY

Annexure – 1

Certificate Number:

PONDICHERY UNIVERSITY
Puducherry – 605 014
Doctoral Degree Programme

REPORT CARD

Name	:		Year of admission	:	
Registration No.	:		Semester	:	
Father's Name	:		Date of Registration	:	
Date of birth	:		Date of Start	:	
College	:	Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal	Date of Closure	:	

Sl. No.	Course Code	Course Title	Credit Hours	Grade Point	Credit Points

E- Incomplete F- Fail S- Satisfactory NS-Not Satisfactory

Credit Status	Upto Last Semester		Current Semester		Cumulative Status	
	Credit Hours	Credit Points	Credit Hours	Credit Points	Credit Hours	Credit Points
Courses completed						
GPA/OGPA						

Prepared by	Checked By	Asst. Registrar (Exams)	Controller of Examinations

Title of the Thesis	:
Total Credit Hours	:
Total Credit Points Obtained	:
Overall Grade Point Average	:
Percentage	:
Class	:
Viva – Voce Completed on	:

Seal:

Date:

**Signature of
CONTROLLER OF EXAMINATIONS**

Classification of OGPA in 10.00 Point Scale.	
9.00 and above	First class with Distinction
8.00 to 8.99	First class
7.00 to 7.99	Second Class

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

LIST OF ENCLOSURES TO BE SUBMITTED ALONG WITH THESIS

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

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. Clearance certificate from Hostel
6. Clearance certificate from Library
7. Clearance certificate from Department
8. Clearance certificate from Staff advisor
9. Clearance certificate from Physical Education
10. Approved registration cards (One set)
11. Report cards (one set)
12. Course completion certificate (signed by Chairperson and HOD)
13. Attendance Certificate
14. Result of comprehensive qualifying examination
15. Permission and fee receipt for availing grace period, if any.
16. Certificate for Anti – Plagiarism (**Proforma 15**).
17. Two copies of paper bound thesis

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 – Four Numbers.
5. Soft copy the thesis in CD (cover to cover in PDF format) - Two Number.

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

**PROPOSAL FOR RECOGNITION OF TEACHERS FOR TEACHING/ GUIDING Ph.D.
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 Master's Programme
- b. Recognition as Guide for Doctoral 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, KARAIKAL – 609 603**

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 :

1. Performance * :

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

APPROVAL OF THE ADVISORY COMMITTEE

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

Proforma-2

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

PERMISSION FOR LATE REGISTRATION

1. Name of the student :
2. Reg. 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
Chairperson :

Signature of the Chairperson

PG Coordinator

Head of the Department

DEAN

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

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

1. Name of the student :
2. Reg. No. :
3. Degree :
4. Subject :
5. OGPA of Master degree :
6. Name of the Chairperson :
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.
I am willing to abide by all the rules and regulations laid down by the College/University in this regard.

Date:

Signature of Student

Chairperson of the Advisory Committee

Head of the Department

DEAN

Proforma-4

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

Proforma for Monitoring Register

Date of meeting	Review of the previous work that was assigned	Remarks of Chairperson	Work assigned for next week	Date on which the student has to report	Signature of the Student	Signature of the Chairperson

Proforma-7

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

Proforma for Obtaining Permission for Re-registration of credits

1. Name :
2. I.D No :
3. Department :
4. Campus :
5. Mention the current semester : Eg. III/IV/V etc.,
6. Re-registration is requested for the semester : IV/V/VI
7. Permission requested for re-registration of :
(a) Course credits : Second/Third time
(b) Seminar credits : Second/Third time
(c) Research credits : Second/Third/Fourth time

Grade Obtained E/NS/EE	Reason for re-registration	Credit hours to be re-registered
---------------------------	----------------------------	----------------------------------

Signature of Student

Chairperson

PG Coordinator

Head of the Department

DEAN

Encl: The following document to be enclosed if re-registration is requested for

Note:

* Example: For Fourth time request: Permission order that was obtained for re-registering third time

* If temporary discontinuance was a reason, then Dean orders to be enclosed.

* For re-registering research credits for second time, the HoD may approve.

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

PROFORMA FOR EVALUATION OF CREDIT SEMINAR

1. Name of the Student :
 2. Register No :
 3. Semester & Academic Year :
 4. Seminar Title :

Sl. No.	Description	Max. Marks	Marks Awarded
1.	Synopsis of the Seminar	10.00	
2.	Presentation		
	a) Introduction	05.00	
	b) Style Clarity	10.00	
	c) Sequence and Organization	05.00	
	d) Topic Coverage	20.00	
	e) Effective use of Audio Visual Aids	05.00	
	f) Time Management	05.00	
	g) Response to Question during discussion	10.00	
3.	Report	30.00	
	TOTAL	100	

Grade: _____

Date:

Signature

Proforma-9

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

DEPARTMENT OF _____

COURSE COMPLETION CERTIFICATE

This is to certify that Thiru./Selvi/Tmt. _____
Reg. No. _____ has completed all the course and research credit requirements
on _____ for the award of Ph.D. (Agri./Horti.) degree
in _____.

Professor and Head

**Signature of the Chairperson
(with Name and designation)**

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

JUSTIFICATION FOR LATE SUBMISSION OF THESIS (if applicable)

1. Name of the student :
2. Reg. 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 Chairperson

Signature of the Chairperson with designation

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

Signature of the Head of the Department

13. Approval of the Dean :

Signature of the Dean

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

PROFORMA FOR EVALUATION OF THESIS

Name of the degree programme: Ph.D. (Agri) in _____.

1. Name and Designation of the examiner :

2. Address of the Examiner:

Telephone/Mobile:

Fax:

E-mail:

3. Name of the candidate:

4. Reg. 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-12

**PONDICHERRY UNIVERSITY
PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE
AND RESEARCH INSTITUTE, KARAIKAL – 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 _____

Reg. 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 Ph.D. thesis in hard bound cover and **TWO** soft copies of thesis in PDF format in CDs.

Head of the Department

**Signature of the Chairperson
with Name and designation**

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

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

(To be sent in triplicate)

1. Name of the student :
2. Reg. No. :
3. Department & College :
4. Name of the Chairperson 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:

Chairperson 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

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

APPLICATION FOR ISSUE OF CONDUCT AND TRANSFER CERTIFICATES

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

1. Name of the student :
2. Reg. No. :
3. Name of the Chairperson :
4. Designation of the Chairperson :
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.

Chairperson

PG Co-ordinator

Professor & Head

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

Proforma for Plagiarism Check

1	Name of the Student	
2	ID Number	
3	Degree	Doctoral
4	Title of the Thesis	
5	Department Name	
6	Campus	
7	Name of the Chairperson	
8	Total Word Count in the Document	
9	Initial Submission If No, If more than 5 times of submission,	Yes / No Provide the number of times plagiarism checked along with their plagiarism percent Provide the details of fine paid
10	Date of Submission	
11	Self-Plagiarism Exclusion Details (if published)	Kindly provide the links of your own publication (URL / DOI) to be excluded 1. 2.

Signature of the Student

Chairman / PG Coordinator / Head of the Department

Doctor of Philosophy (Ph.D.)

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

Credit Requirements

Particulars	Credits
(i) Course Work	
Major courses	12
Minor courses	06
Supporting courses	05
Seminar (2 number)	02
(ii) Thesis Research	75
TOTAL	100

SUPPORTING COURSES

Sl No.	Course Code	Course Title	Credits
01	MAT 601	Advanced Operations Research	2+1
02	STA 601	Applied Regression Analysis	2+1
03	STA 602	Multivariate Analysis for Applied Sciences	1+1
04	COM 601	Programming with R	1+1

MAT 601 Advanced Operations Research 2+1

Aim of the course

To provide an in depth knowledge in formulation of non -linear programming problems, integer programming, and Quadratic Programming. The application problems can be solved by using software packages.

Theory

Unit I

Formulating a nonlinear programming problem – unconstrained and constrained optimization problems – equality constraints - Lagrangian Multipliers-Hessian and bordered Hessian Matrices inequality constraints – Kuhn Tucker conditions.

Unit II

Linear programming -Definitions of primal and dual problems-Duality theorems, Complementary Slackness Theorem-Dual Simplex method – Economic interpolation of duality-Post-Optimal Analysis. Post-optimality Analysis-Changes in the objective function coefficients- Post-optimality Analysis Changes in the bi values- Post-optimality Analysis-Changes in the coefficients a_{ij} 's.

Unit III

Integer programming problems - Gomary's Cutting Plan method - Quadratic programming – Wolfe's modified simplex method- Beale's method. Goal programming problem – Formation and Algorithm- The weights method -The preemptive method

Unit IV

Markov Chains- Definition- Transition probability Matrices – Calculation of n step transition probabilities – Steady state conditions. Simulation – definition – Simulation models –generation of random numbers -Monte Carlo simulation – Application of simulation in queuing systems, maintenance problems, investment and budgeting.

Unit V

Dynamic programming problem- Formulation – Forward and backward, recursive methods- Discrete Dynamic Programming- Continuous Dynamic Programming. Software Packages for solving Operational Research problems

using MS Excel Solver, TORA, R, MATLAB, and other software packages.

Practical

Formulating a nonlinear programming problem - Problems in unconstrained and constrained optimization. Equality and inequality constraints - Kuhn Tucker conditions. Problems in Dual Simplex method – Economic interpolation of duality - Integer programming problems – Gomory's cutting plan method - Problems in quadratic programming, geometric programming– Dynamic programming – Forward and backward recursive methods. Markov decision problem. Transition probabilities – Transition matrices – n step transition probabilities – Steady state conditions – Simulation – definition – Simulation models - Monte Carlo simulation – generating random observations from uniform, exponential and normal probability distributions. Hands on sessions in MS Excel solver – GAMS – MATLAB and other software packages.

Learning Outcome

The students can acquire in depth knowledge in constrained and unconstrained optimization techniques. Also they obtain knowledge in linear and non-linear programming problems and they can solve the problems using software

Lecture Schedule

1. Formulating a non linear programming problem
2. Unconstrained optimization problems –functions of single variables
3. Unconstrained optimization problems –functions of several variables- Hessian Matrices
4. Constrained Optimization-Equality constraints –Lagrangian multipliers- Bordered Hessian matrices
5. Constrained Optimization –Inequality constraints with inequality constraints - Kuhn Tucker conditions
6. Linear programming – Definition of primal and dual
7. Duality theorems, Complementary Slackness Theorem
8. Dual simplex method
9. Economic interpolation of duality
10. Post-optimality Analysis-Changes in the objective function coefficients
11. Post-optimality Analysis-Changes in the b_i values
12. Post-optimality Analysis-Changes in the coefficients a_{ij} 's.
13. Integer programming problems -
14. Gomory's Cutting Plan method
15. Quadratic programming – Wolfe's modified simplex method
16. Quadratic programming – Beale's method.
17. Goal programming problem – Formation and Algorithm
18. The weights method
19. The preemptive method
20. Markov Chains – Definition - Transition probabilities
21. Calculation of n step transition probabilities and Steady State probabilities
22. Simulation definition – Simulation Models – Generation of Random numbers
23. Monte Carlo simulation

24. Application of simulation in queuing and inventory problems.
25. Application of simulation in maintenance and budgeting problems
26. Dynamic programming problem- Formulation – Forward and backward recursive methods
27. Discrete Dynamic Programming
28. Continuous Dynamic Programming
29. Stochastic Programming Problems.
30. Use of MS Excel solver in solving Optimization problems.
31. MATLAB ,GAMS and its features
32. MATLAB ,GAMS and its features
33. Features of other packages in solving OR problems

Practical Schedule

1. Unconstrained optimization problems –functions of single variables
2. Unconstrained optimization problems –functions several variables
3. Problems in Constrained Optimization-Equality constraints
4. Constrained Optimization –Inequality constraints with inequality constraints - Kuhn Tucker conditions
5. Problems in Dual simplex method
6. Integer programming problems - Gomary's cutting plan method
7. Quadratic programming Problems
8. Goal programming formation and solution
9. Discrete Dynamic programming problems
10. Continuous Dynamic programming problems
11. Markov chain-Construction of transition matrices - computation and steady state Probabilities
12. Simulation models- Monte Carlo simulation
13. Simulation in queuing and inventory problems
14. Simulation in maintenance and budgeting problems
15. Solving Use of MS Excel solver
16. Solution by GAMS and MATLAB
17. **Final practical examination**
 1. Fryer MJ and Greenman JV(1987)- Optimisation Theory Applications in OR and Economics, Edward Arnold, London
 2. Hamdy A. Taha (2002) -Operations Research (seventh edition) Prentice Hall of India Publisher, New Delhi.
 3. MJ. Fryer and JV Greenman (1987) Optimization Theory: Applications in OR and Economics, Edward Arnold
 4. Kanti Swarup, P.K Gupta, Man Mohan (1988) Operations Research (latest Edition) Sultan Chand & Sons educational publisher, New Delhi (latest edition).
 5. Michael D. Intriligator (1971), Mathematical Optimization and Economic Theory, Prentice- Hall of India Pvt Ltd., New Delhi

6. Don.T Phillips, Ravindran A. and James J.Solberg 1986 - Operations Research Principles and Practice

Suggested websites

1. http://en.wikipedia.org/wiki/Queueing_model
2. http://en.wikipedia.org/wiki/Dynamic_programming

Aim of the Course

To get depth knowledge and understanding of the linear and non-linear regression model and its limitations.

To learn how to develop regression model and check regression diagnostics and apply for the specific perspective data.

Theory**Unit I: Correlation Analysis**

Introduction to correlation analysis and its measures, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

Unit II: Regression Diagnostics

Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity

Unit III: Regression analysis

Assumption and properties of regression coefficient - Method of least squares for curve fitting; Testing of regression coefficients and intercept. Coefficient of determination

Unit IV: Multiple Regression Analysis

Multiple and partial regressions - Diagnostic of multiple regression equation; Concept of weighted least squares; Various methods of selecting the best regression equation – Forward selection method, Backward elimination method, Stepwise regression

Unit V: Nonlinear Regression Analysis

Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial

Practical

Correlation coefficient and test of significance, Rank correlation. Regression analysis - Method of least squares for curve fitting - testing of hypothesis residuals and their applications in outlier detection; Handling of correlated errors, multi collinearity; - Multiple and partial regressions - Diagnostic of multiple regression equation Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials

Learning Outcome

After completion of this course the students will be able to

- Identify the relationship between the variables and solve problems involving simple and multiple linear regression.
- Select the best regression model and variables contributing to model.
- Carry out regression analysis for given data using different diagnostic measures, transformation.
- Fit linear and Non-linear regression curves and its implementation in real life situation

Lecture Schedule

1. Introduction to correlation analysis and its measures
2. Assumption and properties of correlation coefficient
3. Rank correlation
4. Testing of population correlation coefficients
5. Multiple correlation coefficients and their testing
6. Partial correlation coefficients and their testing
7. Correlation ratio
8. Auto correlation
9. Biserial correlation
10. Problem of correlated errors
11. Removal of auto correlation by transformation
12. Analysis of collinear data
13. Detection of multi collinearity and remedies
14. Correction of multi collinearity
15. Heteroscedastic models
16. Durbin Watson Statistics
17. Introduction to Regression analysis
18. Assumption and properties of regression coefficient
19. Method of least squares for curve fitting
20. Testing of regression coefficients
21. Interpretation of regression coefficient and intercept
22. Partial regressions
23. Multiple regression equation
24. Diagnostic of multiple regression equation
25. Concept of weighted least squares
26. Various methods of selecting the best regression equation - Forward selection method, Backward elimination method
27. Various methods of selecting the best regression equation - Stepwise regression
28. Concept of nonlinear regression
29. Fitting of quadratic curves
30. Fitting of exponential curves
31. Fitting of power curves
32. Economic and optimal dose
33. Orthogonal polynomial

Practical Schedule

1. Calculation of correlation coefficient

2. Calculation of partial correlation coefficient
3. Fitting of multiple linear regression equation
4. Testing of multiple linear regression coefficients
5. Calculation of Residuals and checking assumption of residuals
6. Outlier detection using residuals
7. Handling of correlated errors
8. Detection on multi-collinearity
9. Dealing with multi-collinearity
10. Detection on Autocorrelation
11. Detection on Heteroscedasticity
12. Estimation of linear model
13. Fitting of quadratic curves
14. Fitting of exponential curves
15. Fitting of power curves
16. Fitting of orthogonal polynomials
17. **Final practical examination**

Suggested Readings

1. David G. Kleinbaum, Lawrence L. Kupper, AzharNizam (2007). Applied Regression Analysis and Other Multivariable Methods (Duxbury Applied) 4th Ed.
2. Draper NR and Smith H. 1998. Applied Regression Analysis. 3 Ed. John Wiley.
3. Ezekiel M. 1963. Methods of Correlation and Regression Analysis. John Wiley
4. Kleinbaum DG, Kupper LL, Muller KE and Nizam A. 1998. Applied Regression Analysis and Multivariable Methods. Duxbury Press
5. Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan
6. Kutner MH, Nachtsheim CJ and Neter J. 2004. Applied Linear Regression Models. 4th Ed. With Student CD. McGraw Hill
7. Chatterjee S, Hadi A and Price B.1999. Regression Analysis by Examples. John Wiley
8. Draper NR and Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley
9. David G. Kleinbaum, Lawrence L. Kupper, AzharNizam (2007). Applied Regression Analysis and Other Multivariable Methods (Duxbury Applied) 4th Ed
10. Draper NR and Smith H. 1998. Applied Regression Analysis. 3 Ed. John Wiley.

Suggested Websites

1. https://en.wikipedia.org/wiki/Regression_analysis
2. <http://home.iitk.ac.in/~shalab/course5.htm>

STA 602 Multivariate Analysis for Applied Sciences 1+1

Aim of the Course

- To learn and develop scientific view to deal with multidimensional datasets and its uses in the analysis of research data.

To understand the extensions of univariate techniques to multivariate frameworks and learn to apply dimension reduction techniques used in the data analysis.

Theory

Unit I: Multiple Regression Analysis

Multivariate statistical techniques – multiple linear regression – full model – stepwise regression – Step-up and step-down regression. Logit and Probit regression – two stage least squares – Canonical correlation.

Unit II: Principal Component and Factor Analysis

Principal component analysis – extraction of principal component – interpretation and uses – factor analysis – nature of factor analysis – basic concepts – assumptions of factor analysis – factor loadings – calculated rotated values – communalities – varimax rotation – quartimax rotation orthomax rotation

Unit III: Discriminant Function and Cluster Analysis

Discriminant function analysis – simple and multiple discriminant analysis – selection of variables – Cluster analysis – purpose of cluster analysis – hierarchical clustering – k means clustering dendrogram – interpretation of dendrogram.

Unit IV: Multi-Dimensional Scaling

Multi-dimensional scaling – method – metric and non-metric – interpretation.

Unit V: Reliability and Path Analysis

Reliability analysis – methods – split half method – Cronbach's Alpha – path analysis – path coefficients – direct and indirect effects – path diagram.

Practicals

Multivariate statistical techniques - Full model regression equation - fitting using software - analysis and interpretation. Stepwise regression analysis - Step up method, Step-down method – Stepwise regression analysis using software. Computation of Logit regression equation - two stage least square regression equation - Canonical correlation. Principal components analysis – deriving the components and its interpretation. Factor analysis - with varimax rotation - quartimax and other rotations. Discriminant analysis - simple discriminant analysis - Multiple discriminant analysis. Cluster analysis -k-means method - hierarchical clustering method and dendrogram. Multi- dimensional analysis - Split half method of reliability - Kornbach's Alpha. Path analysis.

Learning Outcome

After completion of this course the students will be able to

- Carry out an extensive exploratory multivariate analysis for a given multivariate

data.

- Interpret statistically the multivariate data through the various multivariate techniques.
- Carry out classification of given multivariate data.
- Solve problems involving multivariate normal distribution and to do good research in agricultural data.

Lecture Schedule

1. Multivariate techniques – introduction and basics – use of SYSTAT software
2. Full model regression equations – selection of variables – fitting – analysis and interpretation
3. Stepwise regression analysis – step up method
4. Stepwise regression analysis – step down method
5. Logit regression equation fitting and interpretation
6. Probit regression equation – fitting and interpretation
7. . Canonical correlations – computation and interpretation
8. Principal component analysis – deriving the components and its interpretation
9. Factor analysis – objective – designing and assumptions – various rotations
10. Deriving factors and assessment of overall fit – interpreting the factors
11. Discriminant analysis – classification of multivariate observations – principles – simple discriminant analysis – equation fitting
12. Multiple discriminant analysis – equation fitting
13. Cluster analysis – principles – steps in clustering – k – means method – hierarchical clustering method – dendrogram – interpreting the dendrogram
14. Multi dimensional analysis technique – method and interpretation
15. Reliability analysis – methods – split half method – Cronbach's Alpha
16. Path analysis – path coefficients – direct and indirect effects – construction of path diagram

Practical Schedule

1. Full model regression equations – fitting using software – analysis and interpretation
2. Stepwise regression analysis – step up method using software
3. Stepwise regression analysis – step down method using software
4. Computation of Logit regression equation
5. Computation of two stage least square regression equation
6. Computation of Canonical correlation
7. Principal components analysis – deriving the components and its interpretation
8. Factor analysis – with varimax rotation
9. Factor analysis – quartimax and other rotations
10. Discriminant analysis – simple discriminant analysis
11. Multiple discriminant analysis
12. Cluster analysis – k-means method
13. Cluster analysis – hierarchical clustering method and dendrogram
14. Multi dimensional analysis
15. Split half method of reliability – Kornbach's Alpha
16. Path analysis
17. **Final practical examination**

Suggested Readings

1. Anderson TW. 1984. An Introduction to Multivariate Statistical Analysis. 2nd Ed. John Wiley
2. Arnold SF. 1981. The Theory of Linear Models and Multivariate Analysis. John Wiley
3. Giri NC. 1977. Multivariate Statistical Inference. Academic Press
4. Johnson RA and Wichern DW. 1988. Applied Multivariate Statistical Analysis. Prentice Hall
5. Kshirsagar AM. 1972. Multivariate Analysis. Marcel Dekker.
6. Muirhead RJ. 1982. Aspects of Multivariate Statistical Theory. John Wiley.
7. Rao CR. 1973. Linear Statistical Inference and its Applications. 2nd Ed. John Wiley
8. Rencher AC. 2002. Methods of Multivariate Analysis. 2nd Ed. John Wiley
9. Srivastava MS and Khatri CG. 1979. An Introduction to Multivariate Statistics. North Holland

Suggested Websites

1. https://en.wikipedia.org/wiki/Multivariate_statistics
2. <https://online.stat.psu.edu/stat505/>
3. https://www.iiap.res.in/astrostat/School08/PennStateSchool08_LecNotes.pdf
4. <https://www.math.uci.edu/~htucker/LectureNotes/MultivariateAnalysis.PDF>
5. <http://i2pc.es/coss/Docencia/ADAM/Notes/MultivariateAnalysisSlides.pdf>
6. <http://www.statslab.cam.ac.uk/~pat/AppMultNotes.pdf>

Aim of the Course

To give an idea about programming in R software and learn how to use R for data visualization

Theory**Unit I**

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

Unit II

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()`;

Unit III

`install.packages()`, `library()`; Introduction to Machine Learning; Introduction to R package tensorflow Introduction to R package keras.

Unit IV

Rscript If, Else, Else If statements in R; For Loop and While Loop in R; R user defined Functions

Unit V

Scatter Plot, Bar Chart and Histogram in R; Data Visualization with R `ggplot2`; Publishing Data Visualizations with R Shiny;

Practical

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()`; `install.packages("tensorflow")`; `install.packages("keras")`; Rscript, If, Else, Else If statements in R; For Loop and While Loop in R; R user defined Functions; Scatter Plot, Bar Chart and Histogram in R; Data Visualization with R `ggplot2`; Publishing Data Visualizations with R Shiny;

Learning Outcome

The course will impart knowledge on how to analyze and visualize data using R programming

Lecture schedule

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

3. R Matrix- Create, Print, Add Column using `cbind()`, Add Row using `rbind()`, Slice using `[,]`;
4. R Data Frame - Create using `data.frame()`, Edit using `edit()`, Append using `cbind()`, `rbind()`, `select()`, `subset()`, sort using `order()`;
5. List in R - Create using `list()`, Select; Data Importing and Exporting in R Using `read.table()` and `write.table()`;
6. `install.packages()`, `library()`;
7. `install.packages("tensorflow")`;
8. `install.packages("keras")`;
9. Rscript
10. If, Else, Else If statements in R;
11. For Loop in R;
12. While Loop in R;
13. R user defined Functions
14. Scatter Plot, Bar Chart and Histogram in R;
15. Data Visualization with R `ggplot2`;
16. Publishing Data Visualizations with R Shiny;

Practical Schedule

1. R Console; R Vector creation using `c()`; R Assignment operators `= <-` ;
2. R Matrix- Create, Print, Add Column using `cbind()`,
3. Add Row using `rbind()`, Slice using `[,]`;
4. R Data Frame - Create using `data.frame()`, Edit using `edit()`, Append using `cbind()`, `rbind()`, `select()`, `subset()`, sort using `order()`;
5. List in R - Create using `list()`, Select; Data Importing and Exporting in R Using `read.table()` and `write.table()`;
6. `install.packages()`, `library()`;
7. `install.packages("tensorflow")`;
8. `install.packages("keras")`;
9. Rscript
10. If, Else, Else If statements in R;
11. For Loop in R;
12. While Loop in R;
13. R user defined Functions;
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**

Suggested Readings

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

Suggested Websites

1. RStudio.com Shiny Tutorial - <https://shiny.rstudio.com/tutorial/> - <https://shiny.rstudio.com/articles/>
2. R Interface to Tensorflow - <https://tensorflow.rstudio.com/>
3. R Interface to Keras - <https://keras.rstudio.com/>

Ph.D.
Vegetable Science

Ph.D. Vegetable Science

Sl No.	Course code	Course Title	Cr. Hr.
I. Major courses (12 credits)			
01	VSC 601*	Recent trends in vegetable production	3+0
02	VSC 602*	Advances in breeding of vegetable crops	3+0
03	VSC 603	A biotic stress management in vegetable crops	2+1
04	VSC 604	Seed Certification, Processing and Storage of Vegetable Seeds	2+1
05	VSC 605	Breeding for Special Traits in Vegetable Crops	2+0
06	VSC 606	Biodiversity and conservation of vegetable crops	2+1
07	VSC 607	Biotechnological Approaches in Vegetable Crops	2+1
08	VSC 608	Advanced Laboratory Techniques for Vegetable Crops	1+2
II. Minor Courses (6 credits)			
III. Supporting Courses (5 credits)			
IV. Seminar (2 credits)			
01	VSC 691	Doctoral Seminar	0+1
02	VSC 692	Doctoral Seminar	0+1
V. Thesis Research (75 credits)			
01	VSC 699	Doctoral Research	0+75

* Courses to be compulsorily registered

VSC 601 Recent Trends in Vegetable Production (3+0)

Aim of the course

To keep abreast with latest developments and trends in production technology of vegetable crops.

The course is constructed given as under:

Theory

Unit I

Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.

Unit II

Cole crops: Cabbage, cauliflower and knol-khol, sprouting broccoli.

Unit III

Okra, onion, peas and beans, amaranth and drumstick.

Unit IV

Root crops and cucurbits: Carrot, beet root, turnip, radish and cucurbits

Unit V

Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

LectureSchedule

Unit I

1. Present status and prospects of vegetable cultivation
2. **Tomato** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
3. **Brinjal** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.

4. **Brinjal** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
5. **Chilli** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
6. **Chilli** -role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
7. **Sweet pepper** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
8. **Sweet pepper** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
9. **Potato** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
10. **Potato** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.

Unit II

11. **Cabbage** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.

12. **Cabbage** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
13. **Cauliflower** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
14. **Cauliflower** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
15. **Knolkhol** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
16. **Knolkhol** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
17. **Sprouting broccoli** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
18. **Sprouting broccoli** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.

Unit III

19. **Okra** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic

- manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
20. **Onion** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
 21. **Peas** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
 22. **Peas** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
 23. **Beans** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
 24. **Amaranth** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators ; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
 25. **Drumstick** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery

management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators ; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.

Unit IV

26. **Carrot** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
27. **Carrot** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
28. **Beetroot** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
29. **Beetroot** -role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
30. **Turnip** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators,role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
31. **Radish** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.

32. **Radish** -role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
33. **Cucurbits**- Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management;
34. **Cucurbits** - physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
35. **Cucurbits** - role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.

Unit V

36. **Sweet potato** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
37. **Cassava** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
38. **Elephant foot yam** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators.
39. **Elephant foot yam** -role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management,

- nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
40. **Dioscorea** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
 41. **Taro** - Nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators,
 42. **Taro** -role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching.
 43. Protected cultivation of vegetables,
 44. Containerized culture for year-round vegetable production.
 45. Low-cost polyhouse
 46. Production of vegetables in net house.
 47. Crop modelling,
 48. Organic gardening.
 49. Vegetable production for pigments,
 50. Export and processing of vegetables

Learning outcome

After successful completion of this course, the students are exposed to:

- Acquire the knowledge about recent trends in production technology of vegetable crops

Suggested Reading

1. Bose, T. K and Som, N. G. 1986. *Vegetable crops of India*. Naya Prakash.
2. Bose T. K, Kabir, J, Maity, T.K. Parthasarathy, V. A and Som, M.G. 2003. *Vegetable crops*. Vols. I-III. Naya Udyog.
3. Brewster, J.L. 1994. *Onions and other vegetable alliums*. CABI.

4. Chadha, K.L and Kalloo, G. (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra Publ.House.
5. Chadha, K. L (Ed.). 2002. *Hand book of horticulture*. ICAR.
6. Chauhan, D.V. S (Ed.). 1986. *Vegetable production in India*. Ram prasad and Sons.
7. Fageria, M. S, Choudhary, B.R and Dhaka, R.S. 2000. *Vegetable crops: production technology*. Vol.II. Kalyani.
8. Ghosh, S.P, Ramanujam, T, Jos, J.S, Moorthy, S.N and Nair, R.G. 1988. *Tuber crops*. Oxford and IBH.
9. Gopalakrishanan, T.R. 2007. *Vegetable crops*. New India Publ. Agency.
10. Hazra, P and Som, M.G. 2015. *Seed production and hybrid technology of vegetable crops*. Kalyani Publishers, Ludhiana.
11. Hazra, P. 2016. *Vegetable science*. 2ndEdn, Kalyani publishers, Ludhiana.
12. Hazra P. 2019. *Vegetable production and technology*. New India Publishing Agency, New Delhi.
13. Kallo, G and Singh, K. (Ed.). 2001. *Emerging scenario in vegetable research and development*. Research periodicals and Book Publ. House.
14. Kurup, G.T, Palanisami, M.S, Potty, V.P, Padmaja, G, Kabeerathuma, S and Pallai, S.V. 1996. *Tropical tuber crops, problems, prospects and future strategies*. Oxford and IBH.
15. Rana, M.K. 2008. *Olericulture in India*. Kalyani Publishers, New Delhi.
16. Rana, MK. 2008. *Scientific cultivation of vegetables*. Kalyani Publishers, New Delhi.
17. Saini G.S. 2001. *A Text Book of Oleri and Flori culture*. Aman Publishing House.
18. Salunkhe, D.K and Kadam, SS. (Ed.). 1998. *Hand book of vegetable science and technology: production, composition, storage and processing*. Marcel Dekker.
19. Shanmugavelu, K.G. 1989. *Production technology of vegetable crops*. Oxford and IBH.
20. Singh, D.K. 2007. *Modern vegetable varieties and production technology*. International bookdistributing Co.
21. Singh, N.P, Bhardwaj, A.K, Kumar, A and Singh, K.M. 2004. *Modern technology in Vegetable production*. International book distr. Co.
22. Singh, P.K, Dasgupta, S.K and Tripathi, S.K. 2006. *Hybrid vegetable development*. Internationalbook distr. Co.
23. Thamburaj, S and Singh, N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR.
24. Thompson, H.C and Kelly, W.C. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

Suggested websites:

- <https://www.researchgate.net/topic/Vegetable-Production/publications>
- <https://www.iihr.res.in/>
- <https://iivr.icar.gov.in/>
- <https://www.iari.res.in/index.php/en/>
- <https://avrdc.org/>

VSC 602 Advances in Breeding of Vegetable Crops (3+0)

Aim of the course

To impart knowledge on the recent research trends and advances in breeding of vegetable crops.

The course is constructed given as under:

Theory

Unit I

Solanaceous crops - Tomato, Brinjal, Hot Pepper, Sweet Pepper, Okra and Potato

Unit II

Cucurbits and Cole crops

Unit III

Legumes and leafy vegetables - Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.

Unit IV

Root crops and onion - Carrot, Beetroot, Radish, Turnip, Onion

Unit V

Tuber crops - Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea

Theory Schedule

Unit I

1. Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, biofortification,*in-vitro* breeding, marker assisted breeding, haploidy, development of transgenic of Tomato

2. Brinjal

3. Hot Pepper

4. Sweet pepper

5. Okra

6. Potato

Unit II

7. Pumpkin

8. Squashes

9. Cucumber
10. Ash gourd
11. Bitter gourd
12. Bottle gourd
13. Ridge gourd
14. Sponge gourd
15. Ivy gourd
16. Snake gourd
17. Watermelon
18. Muskmelon
19. Chow-chow
20. Cabbage
21. Cauliflower
22. Brussels sprout
23. Sprouting broccoli
24. Chinese cabbage
- 25&26. Knol khol

Unit III

27. Garden pea
28. Cowpea
29. Cluster bean
30. Indian bean
31. French bean
32. Broad bean
33. Amaranth
34. Palak
35. Spinach
36. Lettuce
37. Chekkurmanis
38. Moringa

Unit IV

39. Carrot
40. Beetroot

41. Radish
42. Turnip
43. Onion
44. Garlic
45. Leek

Unit V

46. Sweet potato
47. Tapioca
48. Elephant foot yam
49. Colocasia
50. Dioscorea
51. Artichoke

Learning outcome

After successful completion of this course, the students are exposed to:

- Breeding objectives and trends
- Recent Advances in vegetable breeding

Suggested readings:

1. Allard RW. 1999. *Principles of plant breeding*. John Wiley and Sons.
2. Basset MJ. (Ed.). 1986. *Breeding vegetable crops*. AVI Publ.
3. Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.
4. Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: Breeding and seed production*. Vol. I. Kalyani.
5. Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.
6. Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.
7. Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.
8. Hazra P and Som MG. 2015. *Vegetable science* (Second revised edition), Kalyani publishers, Ludhiana, 598p.
9. Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459p.
10. Kalloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
11. Kalloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

12. Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. AgroBotanical Publ.
13. Paroda RS and Kalloo G. (Eds.). 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific Region*. FAO.
14. Peter KV and Pradeepkumar T. 2008. *Genetics and breeding of vegetables*. Revised, ICAR.
15. Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
16. Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables Volume II*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.
17. Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables Volume III*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.
18. Rai N and Rai M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
19. Ram HH. 1998. *Vegetable breeding: principles and practices*. Kalyani Publishers, New Delhi.
20. Rout GR and Peter KV. 2008. *Genetic engineering of horticultural crops*. Academic press, Elsevier, USA.
21. Simmonds NW. 1978. *Principles of crop improvement*. Longman. Singh BD. 1983. *Plant Breeding*. Kalyani Publishers, New Delhi.
22. Singh PK, Dasgupta SK and Tripathi SK. 2004. *Hybrid vegetable development*. International Book Distributing Co.
23. Swarup V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

Suggested websites:

- <https://www.britannica.com>
- <https://www.sesric.org>
- <https://agriinfo.in> ›
- <https://www.uidaho.edu>
- <https://icar.org.in>
- <https://agritech.tnau.ac.in>
- <https://www.researchgate.net> ›
- <https://annamalaiuniversity.ac.in>
- <http://ecoursesonline.iasri.res.in>

- <http://courseware.cutm.ac.in>
- <https://www.britannica.com>

VSC 603 Abiotic Stress Management in Vegetable Crops (2+1)

Aim of the course

To update knowledge on the recent research trends in the field of abiotic stress management in vegetables.

- To teach management practices to mitigate abiotic stress in vegetable crops

The course is constructed given as under:

Theory

Unit I

Environmental stress—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

Unit II

Mechanism and measurements—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

Unit III

Soil-plant-water relations—under different stress conditions in vegetable crops production and their management practices.

Unit IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity

Unit V

Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and anti-transpirants in alleviation of different stresses.

LECTURE SCHEDULE

Unit - I

1. Biological Stress – Definition, classification and impact of abiotic stress and significance its management in vegetable crop production
2. Study of abiotic stress factors limiting vegetable crop production
3. Soil physical and chemical properties in relation to plant nutrient availability
4. Impact of deficiency and toxicity of major nutrients in vegetable crop production
5. Impact of deficiency and toxicity of mor nutrients in vegetable crop production
6. Classification of vegetable crops based on stress tolerance
7. Global warming – causes and impact on vegetable production

Unit - II

8. Oxidative stress and anti-oxidative defense mechanism in plants
9. Impact of drought and assessment of drought tolerance in vegetable crop production
10. Drought tolerance mechanism in vegetable crops
11. Drought stress management in vegetable crop production
12. Impact of water logging and its management in vegetable crop production
13. Soil salinity and sodicity – classification and current scenario
14. Mechanism of salt tolerance in plants

Unit - III

15. Role of wild species in vegetable crop production under abiotic stress
16. Vegetable grafting technique – a tool for abiotic stress management
17. Soil – plant - water relation under abiotic stress situations
18. Salinity management in vegetable crop production
19. Heat stress and mechanism of heat tolerance in vegetable crops
20. Management of heat stress in vegetable crop production
21. High temperature stress and its management in vegetable crop production

Unit - IV

22. Techniques of vegetable production under abiotic stress I (drought / heat)
23. Techniques of vegetable crop production under abiotic stress II (water logging / low temperature)
24. Techniques of vegetable crop production under abiotic stress III (salinity / sodicity)
25. Symptoms of frost injury and its tolerance mechanism in plants
26. Approaches for frost and low temperature management in vegetable crop production
27. Plant adaptation to stress

Unit - V

28. Role of protected structures in abiotic stress management
29. Hydroponic vegetable crop production – an alternate approach under stressful environment
30. Aeroponic vegetable crop production – an alternate approach under stressful environment
31. Role of plant growth regulators in vegetable crop production under stress conditions
32. Significance of foliar nutrition in vegetable crop production under stress
33. Antitranspirants – types and significance in vegetable crop production

Practical Schedule

1. Identification of susceptibility and tolerance symptoms for drought in vegetable crops
2. Identification of susceptibility and tolerance symptoms for flooding in vegetable crops
3. Identification of susceptibility and tolerance symptoms for salinity in vegetable crops
4. Identification of susceptibility and tolerance symptoms for sodicity in vegetable crops
5. Identification of susceptibility and tolerance symptoms for heat stress in vegetable crops
6. Identification of susceptibility and toxicity symptoms for nutrients in vegetable crops
7. Measurement of drought tolerance in vegetable crops
8. Measurement of flooding tolerance in vegetable crops
9. Measurement of salinity tolerance in vegetable crops
10. Measurement of heat tolerance in vegetable crops
11. Studies on seed priming in stress alleviation
12. Studies on drought tolerance and susceptibility in vegetable crops
13. Studies on salinity tolerance and susceptibility in vegetable crops
14. Studies on heat tolerance and susceptibility in vegetable crops
15. Studies on the role of PGR in stress alleviation
16. Studies on chemical regulation of stress in vegetable crops
17. Experiment on hydroponic vegetable production
18. Final practical examination

Learning outcome

After successful completion of this course, the students are expected to:

- Acquire the knowledge about effect of different abiotic stresses on vegetables
- Methods to mitigate abiotic stress in vegetables

Suggested Reading

1. Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House.
2. Dwivedi P and Dwivedi RS. 2005. Physiology of abiotic stress in plants. Agrobios.
3. Janick JJ. 1986. Horticultural science. 4th Ed. WH Freeman and Co.
4. Kaloo G and Singh K. 2001. Emerging scenario in vegetable research and development. Research periodicals and book publ. house.
5. Kaloo G. 1994. Vegetable breeding. Vols. I-III. Vedams eBooks.
6. Lerner HR. (Eds.). 1999. Plant responses to environmental stresses. Marcel Decker.
7. Maloo SR. 2003. Abiotic stresses and crop productivity. Agrotech Publ. Academy.
8. Narendra T. et al. 2012. Improving crops resistance to abiotic stress. Wiley and Sons. US.

9. Peter KV and Pradeep Kumar T. 2008. Genetics and breeding of vegetables. (Revised Ed.). ICAR.
10. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume II. Studium Press LLC,
11. P.O. Box 722200, Houston, Texas 77072, USA, 509p.
12. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.
13. Ram HH. 2001. Vegetable breeding. Kalyani.
14. Rao NK. (Eds.). 2016. Abiotic stress physiology of horticultural crops. Springer publication.

Suggested websites:

- www.plantphysiol.org/
- www.biologyonline.org/abiotic_stress
- www.plantsress.com
- <http://www.uv.ac.uk/Nsol21/stress/drougnt.htm>
- www.plantphysiol.org/

VSC 604 Seed Certification, Processing and Storage of Vegetable Seeds (2+1)

Aim of the course

To impart the knowledge on seed certification, processing and storage of vegetable seeds

Theory

Unit I

Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes.

Unit II

Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes.

Unit III

Principles of seed processing, Methods of seed drying and cleaning, seed processing plant- Layout and design, seed treatment, seed quality enhancement, packaging and marketing.

Unit IV

Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post harvest factors).

Unit V

Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation and marketing of seeds.

LECTURE SCHEDULE

Unit I

1. History and concept of seed certification
2. Role and functions of seed certification agency and organizational set up
3. Phases and procedures of seed certification
4. Indian minimum seed certification standards (IMSCS) - general seed certification standards
5. Planning and management of seed certification programmes

Unit II

6. Principles and methods of field inspection, counting procedures and reporting
7. Procedures for issue of liable for rejection (LFR) report, partial rejection and downgrading
8. Post-harvest inspection, processing report, reprocessing and method of assigning seed lot number
9. Seed sampling procedures, sampling intensity, types of samples and despatch to STL
10. Procedure for labeling, sealing and grant of certificate; types and specifications for tags and labels
11. Seed lot validity and revalidation procedures
12. OECD seed certification schemes

Unit III

13. Objectives and principles of seed processing
14. Sequence of seed processing for different crops
15. Principles and methods of seed drying
16. Methods of seed threshing, shelling and ginning
- 17.&18. Methods and machineries for seed cleaning, grading and upgrading
19. Specifications, design and layout of processing plant
20. Principles and methods of pre and mid storage seed treatments, seed treating formulations and equipments
21. Principles, concept and significance of seed quality enhancement techniques
22. Physical, physiological and biological seed quality enhancement techniques
23. Types of packaging materials, methods of bagging, labeling and stacking

Unit IV

24. Principles of seed storage and Harrington's thumb rule
25. Study on storage behaviour of orthodox and recalcitrant seeds
26. Types of storage - open, bulk, controlled and modified atmospheric storage, Germplasm storage, methods of cold storage and techniques of cryopreservation
27. Factors affecting seed longevity in storage (Pre and post harvest factors)

Unit V

28. Study on physical and physiological during seed storage
29. Study on biochemical and molecular changes during seed storage
30. Theories and causes for seed ageing and deterioration during storage
31. Maintenance of seed viability and vigour during storage
32. Method of seed storage

33. Study on seed storage structures
34. Maintenance of seed storage godown and transportation of seeds

PRACTICAL SCHEDULE

1. Preparation of sowing report for varieties and hybrids in transplanted and direct sown crops
2. Practicing online registration of seed farm
3. Field inspection - estimation of area and isolation distance
4. Practicing field counting procedures for row planting and broadcasted varieties and hybrids in row planting, block method and double count
5. Identification of genetic and physical contaminants and practicing roguing operations
6. Assessment of field standards for different crops and reporting
7. Practicing post-harvest inspection in Vegetable crops
8. Visit to seed processing unit, commercial seed stores and studying the procedures of maintaining registers and records
9. Practicing float test, preparation of processing report and assigning seed lot number
10. Practicing bagging, labelling and sealing of certified seed lots
11. Visit to regulatory seed testing
12. Visit to plant quarantine laboratories
13. Conducting physical purity analysis seed germination test, seedling evaluation and reporting results
14. Estimation of seed moisture content
15. Conducting seed germination test and seedling evaluation
16. Biochemical and molecular methods of genetic purity of assessment
17. **Final practical examination**

Learning outcome

After successful completion of this course, the students are expected to:

- Acquire the knowledge on seed certification
- Acquire the knowledge on seed processing and storage

Suggested Reading

- Agarwal PK and Anuradha V. 2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.
- Basra AS. 2000. *Hybrid seed production in vegetables*. CRC press, Florida, USA.

- Bench ALR and Sanchez RA. 2004. *Handbook of seed physiology*. Food products press, NY/

London.

- Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. *Testing of distinctiveness, uniformity and stability for plant variety protection*. IARI, New Delhi

- Copland LO and McDonald MB. 2004. *Seed science and technology*, Kluwer academic press.
- Fageria MS, Arya PS and Choudhry AK. 2000. *Vegetable crops: breeding and seed production*

Vol 1. Kalyani publishers, New Delhi.

- George RAT. 1999. *Vegetable seed production* (2nd Edition). CAB International.
- Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised

edition), Kalyani publishers, Ludhiana, 459p

- Kalloo G, Jain SK, Vari AK and Srivastava U. 2006. *Seed: A global perspective*. Associated

publishing company, New Delhi.

- Singhal NC. 2003. *Hybrid seed production*. Kalyani publishers, New Delhi.

Suggested websites:

- www.gov.mb.ca
- www.agricoop.nic.in
- www.agri.nic.in
- www.fao.org
- www.seednet.gov.in

VSC 605 Breeding for Special Traits in Vegetable Crops (2+0)

Aim of the course

To impart knowledge on recent developments in breeding for improved nutritional quality in important vegetable crops

Theory

Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes. Molecular and biotechnological approaches in breeding suitable cultivars of different crops for micronutrients and color content.

Unit I

Brassica group, carrot and beetroot.

Unit II

Tomato, brinjal, peppers and potato.

Unit III

Green leafy vegetables, Legume crops and okra.

Unit IV

Cucurbitaceous vegetable crops and edible Alliums.

Unit V

Biofortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospects in breeding for quality traits in vegetables.

Theory Schedule

Unit I

1. Important nutrient constituents in vegetables and their role in human diet.
2. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables.
3. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in cole crops.
4. Molecular and biotechnological approaches in breeding suitable cultivars of cole crops for micronutrients and color content.

5. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in carrot.
6. Molecular and biotechnological approaches in breeding suitable cultivars of carrot for micronutrients and color content.
7. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in beetroot.
8. Molecular and biotechnological approaches in breeding suitable cultivars of beetroot for micronutrients and color content.

Unit II

9. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in tomato.
10. Molecular and biotechnological approaches in breeding suitable cultivars of tomato for micronutrients and color content.
11. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in brinjal.
12. Molecular and biotechnological approaches in breeding suitable cultivars of brinjal for micronutrients and color content.
13. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in peppers.
14. Molecular and biotechnological approaches in breeding suitable cultivars of peppers for micronutrients and color content.
15. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in potato.
16. Molecular and biotechnological approaches in breeding suitable cultivars of potato for micronutrients and color content.

Unit III

17. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in green leafy vegetables.
18. Molecular and biotechnological approaches in breeding suitable cultivars of green leafy vegetables for micronutrients and color content.
19. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in legume crops.

20. Molecular and biotechnological approaches in breeding suitable cultivars of legume crops for micronutrients and color content.
21. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in okra.
22. Molecular and biotechnological approaches in breeding suitable cultivars of okra for micronutrients and color content.

Unit IV

23. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in cucumber, pumpkin and squashes.
24. Molecular and biotechnological approaches in breeding suitable cultivars of cucumber, pumpkin and squashes for micronutrients and color content.
25. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in melons and gourds.
26. Molecular and biotechnological approaches in breeding suitable cultivars of melons and gourds for micronutrients and color content.
27. Breeding strategies for developing varieties with improved nutrition for market and industrial purposes in edible *Alliums*.
28. Molecular and biotechnological approaches in breeding suitable cultivars of edible *Alliums* for micronutrients and color content.

Unit V

29. Biofortification in vegetable crops.
30. Genetic engineering for improvement of quality traits in vegetable crops.
31. Bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition.
32. Achievements in breeding for quality traits in vegetables.
33. Future prospects in breeding for quality traits in vegetables.

Learning outcome

After successful completion of this course, the students are expected to:

- Know about various special characters of vegetables
- The recent breeding methods to achieve special characters in vegetables

Suggested readings:

1. Allard RW. 1999. *Principles of plant breeding*. John Wiley and Sons.
2. Basset MJ. (Ed.). 1986. *Breeding vegetable crops*. AVI Publ.

3. Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.
4. Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: Breeding and seed production*. Vol. I. Kalyani.
5. Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.
6. Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.
7. Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.
8. Hazra P and Som MG. 2015. *Vegetable science* (Second revised edition), Kalyani publishers, Ludhiana, 598p.
9. Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459p.
10. Kalloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
11. Kalloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
12. Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. AgroBotanical Publ.
13. Paroda RS and Kalloo G. (Eds.). 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific Region*. FAO.
14. Peter KV and Pradeepkumar T. 2008. *Genetics and breeding of vegetables*. Revised, ICAR.
15. Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
16. Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.
17. Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.
18. Rai N and Rai M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
19. Ram HH. 1998. *Vegetable breeding: principles and practices*. Kalyani Publishers, New Delhi.
20. Rout GR and Peter KV. 2008. *Genetic engineering of horticultural crops*. Academic press, Elsevier, USA.

21. Simmonds NW. 1978. *Principles of crop improvement*. Longman. Singh BD. 1983. *Plant Breeding*. Kalyani Publishers, New Delhi.
22. Singh PK, Dasgupta SK and Tripathi SK. 2004. *Hybrid vegetable development*. International Book Distributing Co.
23. Swarup V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

Suggested websites

- <https://www.intechopen.com>
- <https://www.botanylibrary.com>
- <https://eorganic.info>
- <https://videleaf.com>

VSC 606 BIODIVERSITY AND CONSERVATION OF VEGETABLE CROPS (2+1)

Aim of the course

To understand the status and magnitude of biodiversity and strategies in germplasm conservation of vegetable crops.

The course is organised as follows:

Theory

Unit-I

General aspects: issues, goals and current status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of vegetable crop domestication; current status of germplasm availability/ database of vegetable crops in India

Unit-II

Germplasm conservation: collection, maintenance and characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of vegetable germplasm collections; active and base collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

Unit-III

Regulatory horticulture: Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of vegetable crops germplasm.

Unit-IV

Plant quarantine, phyto-sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act.

Unit-V

GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged vegetable varieties in India.

THEORY SCHEDULE

UNIT I

1. Issues, goals and current status of Biodiversity in vegetable crops
2. Present status of National and International gene centres, needs and challenges, world's major centre of vegetable crops
3. Current status of germplasm availability/database of vegetables in India
4. Principles of PGR exploration, collection, maintenance of vegetable crop germplasm

UNIT II

5. Conservation of genetic resources of vegetable crops
6. Centres of origin of cultivated vegetables, geographical distribution of vegetable crops of Indian origin
7. Methods of ex - situ conservation of vegetable crops germplasm
8. Methods of in situ conservation of vegetable crops germplasm
9. Advances and issues in conservation of biodiversity recalcitrant and orthodox seeds
10. Advances and issues in conservation of biodiversity of vegetative propagation
11. Cryopreservation of pollen and seeds of vegetable crops

UNIT III

12. Inventory of germplasm, introduction of germplasm
13. Components of gene bank - seed gene bank, field gene bank, in vitro repository, Cryogenic bank DNA library and herbarium
14. Intellectual property rights, Plant Variety Protection Authority (Breeder right, Farmers right, PPV and FR Act)

Unit IV

15. Plant quarantine, phyto sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection
16. GIS and documentation of local biodiversity

Unit V

17. Geographical indication, GIS application in horticultural mapping and spatial analysis of field data.
18. Benefits of Geographical indication protection, GI tagged vegetables and its variety in India
19. Origin, distribution, classification, description and botany of tropical and subtropical vegetable crop dynamics of domestication
20. Origin, distribution, classification, description and botany of temperate vegetable crop dynamics of domestication

21. Status of biodiversity of potato
22. Status of biodiversity of Solanaceous vegetables
23. Status of biodiversity of Okra
24. Status of biodiversity of cucurbitaceous vegetables
25. Status of biodiversity of melon and pepo
26. Status of biodiversity of cruciferous crops
27. Status of biodiversity of root crops
28. Status of biodiversity of tuber crops
29. Status of biodiversity of bulb crops
30. Status of biodiversity of legume vegetables
31. Status of biodiversity of leafy vegetables
32. Status of biodiversity of perennial vegetables
33. Policy issues: assessing economic values, conflict over ownership, management and use Data documentation techniques

Practical schedule

1. Field exploration trips- Exercise in collection and characterization
2. Visit to field germplasm unit and documentation of germplasm
3. Practices in maintenance of passport data
4. Practical study of ex situ conservation methods for vegetable crops
5. Practical study of in situ conservation methods for vegetable crops
6. Methods of seed storage for short and long term conservation for vegetable crops
7. Methods of conservation using vegetative propagules
8. In vitro conservation protocols for vegetable crops
9. Study of species diversity in horticultural cropping system
10. Visit to regional conservation centres
11. Characterization of Solanaceous and cruciferous vegetable germplasm
12. Characterization of cucurbitaceous and leafy vegetable germplasm
13. Characterization of tuber and root vegetable germplasm
14. Characterization of legume and bulb vegetable germplasm
15. Use of molecular tools for characterizing species diversity
16. Estimating extent of diversity through collection and analyses of data

17. Final Practical Examination

Learning outcome

- The student would be expected to learn about the significance of germplasm
- Various strategies to conserve it in the present context.

Suggested Reading

1. Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. *Plant genetic resource management*. –
2. *horticultural crops*. Narosa publishing house, New Delhi.
3. Engles JM, Ramanath RV, BrowFrankel OH and Hawkes JG. 1975. *Crop genetic resources for today and tomorrow*. Cambridge University Press, USA.
4. Hancock J. 2012. *Plant evolution and the origin of crops species*. CAB International.
5. Jackson M, Ford-Lloyd B and Parry M. 2014, *Plant genetic resources and climate change*. CABI, Wallingford, UK
6. Moore JN and Ballington JR. 1991. *Genetic resources of temperate Fruit and nut crops*. ISHS,
7. Belgium.
8. Peter KV. 2008. *Biodiversity of horticultural crops*. Vol. II. Daya Publ. House, Delhi.
9. Peter KV. 2011. *Biodiversity in horticultural crops*. Vol.III. Daya Publ. House, Delhi.
10. Rajasekharan PE, Rao V and Ramanatha V. 2019. *Conservation and utilization of horticultural*
11. *genetic resources*. Springer.
12. Rana JC and Verma VD. 2011. *Genetic resources of temperate minor fruits (indigenous and exotic)*. NBPGR, New Delhi.
13. Sthapit *et al.* 2016. *Tropical fruit tree diversity (good practices for in situ and ex situ conservation)*. Bioersivity international. routledge, Taylor and Francis Group.
14. Virchow D. 2012. *Conservation of genetic resources*, Springer Verlag, Berlin

Suggested websites:

- <http://www.nbpgr.ernet.in/>
- <https://cgspace.cgiar.org/handle/10568/45742>

VSC 607 Biotechnological Approaches in Vegetable Crops (2+1)

Aim of the course

To impart latest knowledge in biotechnical advancement in vegetable crops

The course is organised as follows:-

Unit I

Importance and scope of biotechnology – in vegetable crop improvement. *In-vitro*-culture, micro-propagation, anther culture, pollen culture, ovule culture, embryoculture, endosperm culture.

Unit II

Somatic embryogenesis – somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.

Unit III

Blotting techniques, DNA finger printing – Molecular markers/ DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes. QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco-TILLING.

Unit IV

Plant genetic engineering – Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Biosafety issue, regulatory issues for commercial approval.

Unit V

Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER)

Crops

Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, onion, potato and leafy vegetables

LECTURE SCHEDULE

UNIT – I

1. Scope and Importance of biotechnology in vegetable crop improvement
2. In vitro and micro propagation in vegetable crops

3. Anther & Pollen culture in vegetable crops
4. Ovule & Embryo culture in vegetable crops
5. Endosperm and meristem culture in vegetable crops

UNIT- II

6. Somatic embryogenesis in vegetable crops
7. Somaclonal variation for vegetable crop improvement
8. Micro-grafting in vegetable crops
9. Protoplast isolation, culture and fusion in vegetable crops
10. Somatic hybrids and their application in vegetable crop improvement
11. Cryopreservation and its application in vegetable crops
12. Synthetic seed production in vegetable crops

UNIT- III

13. Importance and application of Blotting techniques
14. Importance and application of DNA finger printing
15. Importance of molecular markers
16. &17. Application of DNA based markers in vegetable crops-I
18. Application of DNA based markers in vegetable crops-II
19. Importance of QTL mapping in vegetable crop improvement
20. MAS and its application in vegetable crop improvement.
21. Allele mining by TILLING and Eco-TILLING.

UNIT - IV

22. Plant genetic engineering - Scope and importance
23. Concepts of cisgenesis, intragenesis and transgenesis.
24. Application of transgenics in development of varieties for resistance
25. Application of transgenics in development of varieties for quality improvement
26. Gene cloning techniques
27. Bio-safety, regulatory issues for commercial approval.

UNIT- V

28. Application of genome editing in vegetable crop improvement
29. Application of genome editing in vegetable crop improvement
30. Role of RNAi based gene silencing in vegetable crop improvement.
31. Concepts and methods of next generation sequencing (NGS)
32. Transcriptomics in vegetable crop improvement
33. Proteomics in vegetable crops
34. Metabolomics in vegetable crops

PRACTICAL SCHEDULE

1. Introduction to micro-propagation
2. In vitro shooting and rooting
3. Pollen culture method
4. Ovule culture method
5. Embryo culture method
6. Synthetic seed production
7. Induction of in vitro mutation
8. Hardening of plantlets
9. Isolation of DNA from economically important vegetable crop varieties
10. Quantification and amplification of DNA
11. DNA and Protein profiling
12. Use of molecular markers for characterization
13. Genetic transformation techniques
14. Genome editing procedures
15. Visit to commercial TC units
16. Project preparation for establishment of low, medium and high cost tissue culture laboratories
17. Final practical examination

Learning outcome

The student would be expected to learn

- Different biotechnological tools
- NGS, genetic engineering

Suggested Reading

1. Bajaj YPS. (Ed.). 1987. *Biotechnology in agriculture and forestry*. Vol. XIX. Hitech and Micropropagation. Springer.
2. Chadha KL, Ravindran PN and Sahijram L. (Eds.). 2000. *Biotechnology of horticulture and plantation crops*. Malhotra Publ. House.
3. Debnath M. 2005. *Tools and techniques of biotechnology*. Pointer publication, New Delhi.
4. Glover MD. 1984. *Gene cloning: the mechanics of DNA manipulation*. Chapman and Hall.
5. Gorden H and Rubsell S. 1960. *Hormones and cell culture*. AB Book Publ.
6. Keshavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New India Publ. Agency.
7. Keshavachandran R and Peter KV. 2008. *Plant biotechnology; tissue culture and gene transfer*. Orient and Longman, USA.
8. Keshavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New-India Publication Agency, New Delhi.
9. Panopoulos NJ. (Ed.). 1981. *Genetic engineering in plant sciences*. Praeger Publ.
10. Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. *Biotechnology of horticultural crops*. Vols. I-III. Naya Prokash.
11. Pierik RLM. 1987. *In-vitro culture of higher plants*. Martinus Nijhoff Publ.
12. Prasad S. 1999. *Impact of plant biotechnology on horticulture*. 2nd Ed. Agro Botanica.
13. Rout GR and Peter KV. 2018. *Genetic engineering of horticultural crops*. Academic Press Elsevier, USA.
14. Sharma R. 2000. *Plant tissue culture*. Campus Books.
15. Singh BD. 2010. *Biotechnology- expanding horizons*. Kalyani Publishers, New Delhi.
16. Skoog Y and Miller CO. 1957. *Chemical regulation of growth and formation in plant tissue cultured in-vitro*. Attidel. II Symp. On biotechnology action of growth substance.

17. Vasil TK, Vasi M, While DNR and Bery HR. 1979. *Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture*. Planum Press.

Suggested websites:

- <http://vric.ucdavis.edu>
- <https://icar.org.in>
- <https://www.hrpub.org>
- <https://www.ijcmas.com>
- <https://www.actahort.org>

VSC 608 Advanced Laboratory Techniques for Vegetable Crops (1+2)

Aim of the course

To familiarize with the laboratory techniques for analysis of vegetable crops.

The organisation of the course is as under:

Unit I

Safety measures and laboratory maintenance – Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration) and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

Unit II

Destructive and non-destructive analysis methods – Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

Unit III

Chromatographic and microscopic analysis- basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.

Unit IV

Sensory analysis – Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

Theory schedule

UNIT- I

1. Good laboratory practices- Safety measures and laboratory maintenance: Safety aspects and upkeep of laboratory
2. Sampling procedures for quantitative analysis
3. Preparation of stock and standard solutions for analysis
4. Calibration of instruments
5. Standardization of instruments
6. Textural properties of harvested produce - Assessment of TSS, specific gravity, pH and acidity

UNIT- II

7. Destructive and non-destructive analysis methods: Refractometry
8. Destructive and non-destructive analysis methods: spectrophotometry
9. Destructive and Non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops

UNIT- III

10. Chromatographic Analysis-Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques and ultra-filtration
12. Application of nuclear techniques in harvested produce for extending shelf-life
13. Advanced microscopic techniques - Scanning Electron Microscope (SEM)
14. Advanced microscopic techniques - Transmission Electron Microscope (TEM)
15. Advanced microscopic techniques- Phase contrast microscope

UNIT- IV

16. Sensory Analysis in fruit crops
17. Sensory analysis techniques- control for test room, products and panel

PRACTICAL SCHEDULE

1. Safety measures in labs and handling of chemical substances
2. Common laboratory equipments.
3. Calibration and cleanliness of volumetric glass wares.
4. Methods of expressing strength of solutions.
5. Preparation of primary standard solutions and buffer solutions.
6. Preparation of standard solutions for nutrient analysis of soil, plant and water.
7. Preparation of different agro-chemical doses for field experiments, preparation of buffer solutions.
8. Handling of instruments.
9. Determination of moisture.
10. Determination of relative water content.
11. Determination of physiological loss in weight.
12. Calibration and standardization of instruments.
13. Textured properties of harvested produce.
14. Determination of TSS, pH and acidity.
15. Determination of fibre.
16. Determination of protein.

17. Determination starch index (SI).
18. Determination of specific gravity for maturity assessment.
19. Detection of adulterations in fresh products.
20. Detection of adulterations in processes products.
21. Introduction of destructive and non-destructive analysis methods.
22. Non- destructive determination of colour.
23. Non-destructive determination of ascorbic acid.
24. Non-destructive determination of vitamins.
25. Non-destructive determination of carotenoids.
26. Non-destructive determination of sugars and starch.
27. Introduction on chromatographic and microscopic c analysis.
28. Study of basic chromatographic techniques.
29. Study of GC, HPLC and GCMS.
30. Study of electrophoresis techniques and ultra-filtration.
31. Introduction on advanced microscopes.
32. Use of advanced microscope-Fluorescent microscope.
33. Use of advanced microscope – Scanning electron microscope and phase contrast microscope.
34. Practical examination

Learning outcome

The students would be expected to develop skills and expertise on

- Upkeep of laboratories and handling of research instruments
- Principles and methods of various analysis

Suggested Reading

1. AOAC International. 2003. Official methods of analysis of AOAC international. 17th Ed. Gaithersburg, MD, USA, association of analytical communities, USA.
2. Clifton M and Pomeranz Y. 1988. Food analysis – laboratory experiments. AVI publication, USA. Linskens HF and Jackson JF. 1995. Fruit analysis. Springer.
3. Leo ML. 2004. Handbook of food analysis, 2nd Ed. Vols. I-III, USA. Pomrenz Y and Meloan CE. 1996. Food analysis – theory and practice. CBS, USA.
4. Ranganna S. 2001. Handbook of analysis and quality control for fruit and vegetable products.

2nd Ed. Tata-McGraw-Hill, New Delhi.

5. Thompson AK. 1995, Postharvest technology of fruits and vegetables. Blackwell sciences.
USA

Suggested websites:

- https://agricoop.nic.in/sites/default/files/ICAR_7.pdf
- <https://www.iihr.res.in/division-vegetable-crops>
- https://www.researchgate.net/publication/338734798_Advanced_Breeding_Tools_in_Vegetable_Crops
- <https://www.fao.org/3/i3284e/i3284e.pdf>