



**ANNAMALAI UNIVERSITY**

(Accredited with 'A' Grade by NAAC)

**FACULTY OF AGRICULTURE**

(Accredited by ICAR)



**DEPARTMENT OF HORTICULTURE**

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**Academic Regulations and Syllabi**

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**DOCTOR OF PHILOSOPHY IN  
FRUIT SCIENCE**

**Under Choice Based Credit System (CBCS)  
with Outcome based Education**

**2022-2023 Onwards**

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

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

## 1. DEFINITIONS

- 1.1 An “**Academic year**” shall consist of two semesters.
- 1.2 “**Semester**” means an academic term consisting of 110 instructional days excluding final theory examinations.
- 1.3 “**Course**” means a unit of instruction to be covered in a semester having specific No., title and credits.
- 1.4 “**Credit hour**” means, one hour lecture plus two hours of library or homework or two and half hours of library/field practical per week in a semester.
- 1.5 “**Credit load**” of a student during a semester is the total number of credits registered by that student during that particular semester.
- 1.6 “**Grade Point**” of a course means the value obtained by dividing the percentage of marks earned in a course by 10 and the Grade Point is expressed on a 10 point scale and rounded off to two decimal places.
- 1.7 “**Credit Point**” means the grade point multiplied by corresponding credit hours.
- 1.8 “**Grade Point Average (GPA)**” means the quotient of the total credit points obtained by a student in various courses at the end of each semester, divided by the total credit hours taken by the student in that semester. The grading is done on a 10 scale and the GPA has to be corrected to two decimals.
- 1.9 “**Overall Grade Point Average (OGPA)**” means the quotient of cumulative credit points obtained by a student in all the courses taken from the beginning of the first semester of the year divided by the total credit hours of all the subjects which he/she had completed up to the end of a specified semester and determines the overall performance of a student in all subjects during the period covering more than one semester. The OGPA has to be arrived at the second decimal place.

## 2. SYSTEM OF EDUCATION

- 2.1 These rules and regulations shall govern the Ph.D. programmes leading to the award of Degree of Doctor of Philosophy in the concerned subject in the Faculty of Agriculture, Annamalai University. They shall come into force with effect from the academic year 2022-2023.
- 2.2 The semester system shall be followed for all the Ph.D. degree programmes. The duration of doctoral programmes is as follows:
  - 2.2.1 The duration of the programme and the time for admission of thesis are counted from the date of provisional registration.
  - 2.2.2 The minimum duration of the programme is three years and the maximum duration of the programme shall be seven years.
  - 2.2.3 Break of study shall be granted up to a maximum period of one year and it can be done only after completing the course work. Such request shall be made in advance by scholar in writing with the recommendation of Supervisor, Head of the Department (HoD) and Dean, Faculty of Agriculture and it should reach the Director, Directorate of

Academic Research (DARE). The orders for the break of study shall be issued by the Director, DARE after assessing the need.

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

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

### 3. PROGRAMMES OFFERED

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

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

### 4. ELIGIBILITY FOR ADMISSION

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

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

4.2 Candidates who have undergone the programme under conventional system should possess not less than a second class Master's degree. The candidates under trimester system should possess a minimum OGPA of 3.00 out of 4.00. For those under semester system 7.00 out of 10.00 is required for various Doctoral programmes.

**Table 1: Eligibility Criteria**

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

4. Agricultural Extension Education	M.Sc. (Ag.) in Agricultural Extension / Agricultural Extension and Communication / Agricultural Extension Education / Extension Education
5. Agricultural Microbiology	M.Sc. (Ag.) in Agricultural Microbiology
6. Agronomy	M.Sc. (Ag.) in Agronomy
7. Genetics and Plant Breeding	M.Sc. (Ag.) in Genetics and Plant Breeding
8. Horticulture	M. Sc (Ag.) Hort. / M.Sc. (Hort.) / M.Sc. (Hort.) in Fruit Science / Vegetable Science / Floriculture and Landscape Gardening or Architecture / Plantation, Spices, Medicinal and Aromatic Crops
9. Plant Molecular Biology and Biotechnology	M.Sc. (Ag.) in Plant Molecular Biology / Agricultural Biotechnology
10. Plant Pathology	M.Sc. (Ag.) in Plant Pathology
11. Seed Science & Technology	M.Sc. (Ag.) in Seed Science & Technology
12. Soil Science	M.Sc. (Ag.) in Soil Science

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

4.3.1 The Ph.D. scholars shall report in the Department and sign every day in the attendance register. In order to promote quality research and training in cutting edge areas, the University may permit the scholar to pursue his research work in Annamalai University or in other Universities/Research Institutes by entering with/without MOU between Annamalai University and the partner University/Institute after the completion of qualifying Viva voce examination.

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

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

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

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

## 5. MODE OF SELECTION

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

5.2. The candidates desirous of registering for Ph.D. programme shall apply by filling all the relevant details mentioned in the online application form posted in the University website and submit completed application online before the due date as indicated in the notification issued from time to time.

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

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

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

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

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

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

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

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

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

5.7. The DRC has the following functions

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

5.7.2 Facilitating research facilities in the Department.

5.7.3 Maintenance of research quality and quality of publications.

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

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

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

## 6. ADMISSION

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

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

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

## 7. TUITION FEES AND OTHER FEES

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

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

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

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

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

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

## 8. CREDIT GRADE POINT REQUIREMENTS

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

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

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

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

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

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

## **9. ATTENDANCE REQUIREMENT**

9.1 One hundred per cent attendance is expected from each scholar. A student who fails to secure 80 per cent of attendance in each subject separately for theory and practical, shall not be permitted to appear for the final examination in that subject and shall be awarded 'E' (incomplete) and will be required to repeat the course whenever offered.

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

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

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

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

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

## **10. RESEARCH ADVISORY COMMITTEE**

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

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

10.3 There shall be a Research Advisory Committee for every student consisting of not fewer than four members with the Supervisor as Chairperson. The Research Advisory Committee should have representatives from the major and minor fields. The major **Advisor/Research Advisor** will be from Annamalai University and Co-Research Supervisor will be from the partner institutes (Research Scholars pursuing in other institutes/universities) besides RAC members.

The Research Supervisor should convene a meeting of the Research Advisory Committee at least once in a semester. The research credit evaluation form should be communicated to the Head of Department and the Director, DARE for information.

### **10.4 Research Supervisor**

10.4.1 Every scholar shall have a Research Supervisor (among the recognized guides), who will be appointed by the Vice-Chancellor on the recommendation of the DRC, Head of the Department and the Dean, Faculty of Agriculture. Research supervisors approved by the Vice-Chancellor only can be the guide for the students.

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

10.4.3 The research supervisors who wish to avail leave/lien/deputation beyond a period of six months shall propose a Co-supervisor in the concerned subject for the candidates registered with them and it may be intimated to the University well in advance. The final approval of the proposal rests with the Vice-Chancellor.

### **10.5 Functions of the RAC:**

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

10.5.2 Approve the topic of research and the synopsis.

10.5.3 Assess and approve the progress reports of Ph.D. scholars in the prescribed format and to report to the University on the fitness or otherwise of the candidate to proceed with his/her research work for the Ph.D.

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

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

10.6 The Research Advisory Committee will meet every semester

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

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

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



10.6.4 To approve the synopsis of the thesis.

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

#### **10.7 Changes in RAC**

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

#### **10.8 Change of Research Supervisor**

10.8.1 Change of Research Supervisor shall not be permitted as a routine. In exceptional cases, such change may be permitted, if valid reasons are provided by the candidates. The Committee headed by the Vice-Chancellor shall look into the request of the petitioner, if there is any conflict between the scholar and the research supervisor.

10.8.2 The Research Supervisor under whom the scholar has originally registered shall give a "No Objection Certificate" and the new proposed Research Supervisor should give a "Certificate of Willingness" to guide the candidate. The final decision will rest with the University. However, the Vice-Chancellor, on the recommendation of the RAC and Dean's Committee, has the right to assign a new research supervisor to the research scholar.

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

#### **10.9 Change of Topic of Research**

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

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

#### **10.10 Absence of Member during Qualifying / Final Viva-Voce Examination**

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

### **11. EVALUATION OF STUDENT'S PERFORMANCE**

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

### **12. EXAMINATIONS**

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

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

12.2.1 The first test will be conducted by course teachers during the ninth week of the semester as per the scheme drawn by HOD, evaluate and send the marks obtained by the students to the Director, DARE through HOD within seven working days.

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

12.2.3 There will be final examination separately for theory and practical which will be conducted by the University. Each final theory and practical examinations will be evaluated by two examiners (one will be the course teacher and another will be the senior faculty of the Department).

The distribution of marks will be as indicated below:

S. No	Examination	Course with practical	Course without practical	Course without theory
1	First Test	30	30	30
2	Final theory	40	70	-
3	Final practical	30	-	70
	<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>

The question paper model and distribution of marks for first test and final theory examinations are as follows:

**First Test (30 marks) (1.5 hours duration)**

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

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

1.	Short notes	5 out of 7	(5 x 4)	20 marks
2	Essay type	5 out of 7 (four questions must represent K6 level of Bloom's taxonomy)	(5 x 10)	50 marks

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

1.	Short notes	5 out of 7	(5 x 2)	10 marks
2	Essay type	5 out of 7 (four questions must represent K6 level of Bloom's taxonomy)	(5 x 6)	30 marks

**12.3 Minimum Marks for Pass**

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

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

12.3.2 Students who secure marks below 70 per cent in a subject will be awarded 'RA' grade and students without having the required minimum attendance of 80 per cent will not be allowed to write the final examination and they will be awarded 'E' grade. Students who secure 'RA' grade should appear for re-examination in the subsequent semester. If a student secured 'E' grade, he/she has to re-register and attend the course again during the next academic year.

#### **12.4 Minimum GPA Requirement**

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

- a) Earn a Grade Point of 7.00 for a pass in each subject.
- b) For purpose of continuing as a student in the university, a candidate is required to earn a Grade Point Average of not less than 7.50 at the end of each semester.
- c) A Ph.D. student may repeat the course (s) in which he/she gets a Grade Point below 7.50 and above 7.0 to improve the OGPA.

#### **12.5 Re-Examination**

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

12.5.2 The re-examination fee as prescribed by university per course is to be paid on or before the prescribed date. A student is permitted to write the final theory and practical examinations only two times during the course period of three years excluding the regular final examination.

12.5.3 In the event of a student who fails to secure a pass in the two re-examinations permitted, he/she has to re-register for the course along with juniors. The marks secured in first test will be retained and the student should produce the practical record during re-examination. The registration for the re-examination shall be done after first test on the date specified by the Director, DARE. Each registration is considered as an attempt even if the student absents for the examination.

#### **12.6 Return of Valued Answer Papers**

12.6.1 The valued answer papers of first test shall be shown to the students after the examination. Discrepancies if any, in awarding marks, the student can approach the teacher concerned immediately for rectification.

12.6.2 The answer paper should be retained with the course teacher for six months and then disposed off. Evaluated final theory papers have to be retained up to six months by the Director, DARE after the conduct of examination and then disposed off.

### **13. SEMINAR**

Seminar is compulsory for all students and each student should register and present two seminars each with 0+1 credits. A student can register only one seminar in a semester

and only after successful completion of the first seminar, the student is permitted to register for the second seminar.

### 13.1 Seminar Topic

13.1.1 The seminar topic should be only from the major field and should not be related to the area of thesis research. The seminar topics are to be assigned to the students by the Research Supervisor in consultation with HOD within three weeks after commencement of the semester.

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

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

13.1.4 The student will submit two copies of the corrected manuscript to the HOD through Research Supervisor before presentation. The student will incorporate the suggestions and carry out corrections made during the presentation and resubmit three fair copies to the HOD (one to Dept. library, the second to the Research Supervisor and the third for student) within 15 days after presentation.

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

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

## 14. QUALIFYING EXAMINATION

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

### 14.1 Minimum requirement for qualifying Viva-voce Examination

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

### 14.2 Selection of Examiner

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

#### 14.3 Qualifying Viva-Voce Examination

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

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

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

#### 14.4 Communication of Results of Qualifying Examination

The Research Supervisor shall act as chairman for the examination committee and shall be responsible for communicating the results of the examination to the Director, DARE through HOD in the prescribed format.

#### 14.5 Failure /Absence in Qualifying Examination

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

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

14.5.3 If a student fails in the re-examination, further re-examination will be considered on the recommendation of the RAC, HoD and Dean, Faculty of Agriculture. If the student fails in the qualifying examination, he/she is not permitted to register for further research credits in the next semester.

## 15. THESIS RESEARCH

### 15.1 Selection of Topic

15.1.1 The thesis research for the Ph.D. degree should be of the nature of a definite contribution to the subject and the results should be of sufficient importance to merit publication. The findings should have some practical utility or should lead to theoretical contribution.

15.1.2 The thesis shall be on a topic falling within the field of the major specialization and shall be the result of the student's own work. A certificate to this effect duly endorsed by the major advisor shall accompany the thesis

### 15.2 Research Proposal

15.2.1 The research scholars shall present their broad area of research and submit a proposal to the Research Advisory Committee at the end of the first semester.

15.2.2 The research proposal has to be presented by the student in a meeting organized by the Head of the Department to get the opinion / suggestion of the faculties of the Department for improving it. Three copies of the research proposal in the prescribed

format should be sent to the Director (DARE) through the Head of the Department for approval.

15.2.3 The distribution of research credit will be as follows:

<b>Semester</b>	<b>Credit Hours</b>
I Semester	0+2
II Semester	0+10
III Semester	0+16
IV Semester	0+16
V Semester	0+16
VI Semester	0+15
<b>Total</b>	<b>0+75</b>

### 15.3 Evaluation of Thesis Research

15.3.1 After assigning the research problem, for each semester, the student has to submit a detailed programme of work to be carried out by him/her during the semester in the prescribed proforma. After scrutiny and approval, a copy of the research programme has to be given to the student for carrying out the work during that semester.

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

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

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

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

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

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

15.3.8 The procedure of evaluating research credits under different situations are explained hereunder.

#### SITUATION – I

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

## **SITUATION – II**

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

## **SITUATION – III**

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

- Failure of crop
- Non-incidence of pests or disease or lack of such necessary experimental conditions.
- Non-availability of treatment materials like planting materials chemicals, etc.
- Any other impeding / unfavorable situation for satisfying the advisory committee.
- Under the said situations, grade **EE** should be awarded.

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

## **SITUATION – IV**

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

For the registration of research credits for the third time, permission has to be obtained from the Dean based on the recommendation of the RAC, and HOD.

Permission for registration for the fourth time shall be given only by the University based on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

## **16. SUBMISSION OF THESIS**

16.1 The research credits registered in the last semester should be evaluated only at the time of the submission of thesis, by the RAC. Students can submit the thesis at the end of the final semester.

16.2 If a student has completed the thesis before the closure of the final semester, the research supervisor can convene the RAC meeting and take decision on the submission of the thesis, provided the student satisfies 80 per cent attendance requirement.

16.3 The candidate shall be allowed to submit his/her thesis after the completion of stipulated period. A grace period of 30 days may be allowed to submit the thesis after the prescribed duration. If the thesis is not submitted even after the grace period, the student shall pay the tuition fee for the ensuing year.

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

16.5 Three copies of the thesis (in the approved format) shall be submitted together with the submission fee not later than three months after the submission of the synopsis.

16.6 No dues certificates from the Department and Central Libraries, Hostel, Stores, etc. must be submitted with the thesis copies. The Research Supervisor shall forward the thesis copies with the enclosures to the Director, DARE through the HOD and the Dean. A soft copy of the thesis in PDF format as prescribed by Shodhganga, shall also be submitted.

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

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

#### **16.9 Pre-submission Presentation**

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

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

16.9.3 A report on this event along with an attendance sheet shall be forwarded by the Research Supervisor with the endorsement of the RAC and HOD to the Director, DARE.

#### **16.10 Submission of Synopsis**

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

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

16.10.3 Guidelines for the preparation of the synopsis are appended in Appendix I. Name of the candidate and name of the supervisor shall not be mentioned anywhere in the synopsis; enrolment number of the candidate alone shall be given. A model cover page for a synopsis is given in Appendix III.

#### **16.11 Guidelines for Preparation of Thesis**



16.11.1 The thesis shall not exceed 250 pages excluding the Bibliography, Appendices, etc. If it exceeds the specified number of pages, the Research Supervisor should write to university with the reasons and get prior approval from the University. The candidate shall pay a penalty for the excess number of pages as decided by the Deans Committee. The thesis should be in A4 size.

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

16.11.3 The thesis shall be typed on both sides of the page in order to save paper and postage. The thesis shall contain a Certificate from the guide (Annexure) specifying that the thesis submitted is a record of research work done by the candidate during the period of study under him/her and that the thesis has not previously formed the basis for the award of any Degree, Diploma, Associateship, Fellowship or similar title.

16.11.4 A statement from the guide indicating the extent to which the thesis represents independent work on the part of the candidate should also be made. (Appendix V)

## **16. VALUATION OF THE THESIS**

### **17.1 Panel of Examiners**

17.1.1 The thesis submitted in partial fulfilment of the Ph.D. degree shall be evaluated by two external experts one from within the country and the other from outside the country appointed by the Vice-Chancellor on the recommendation of the Research Supervisor of the RAC, HOD and Dean.

17.1.2 The external experts shall be chosen from a panel of at least five names of specialists separately from within the country and outside the country in the particular field, suggested by the Research Supervisor.

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

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

17.1.5 After a student's thesis for Ph.D. degree is evaluated as indicated above, the thesis shall be finally accepted for the award only after the student satisfactorily completes the final Viva-voce examination.

17.1.6 The Viva-Voce board comprises the student's RAC with the addition of the external examiner who valued the thesis, and the HOD. If the HOD happens to be the Research Supervisor, the Dean, Faculty of Agriculture will nominate a senior member of the staff of the concerned Department as a member.

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

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

17.1.9 A candidate who is not successful (unsatisfactory) at the Viva-voce examination will be permitted to undergo the Viva-voce examination again within a period of three months

### **17.2 Revision and Resubmission of Thesis**

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

17.2.2 If the thesis is recommended to be revised by one or both examiners, the points of revision will be indicated clearly in the report. The necessary correction should be carried out, and the revised version should be sent to the concerned examiner(s). If the examiner(s) is / are still not satisfied with the revised version, the thesis will be rejected. If the thesis is accepted by the examiners (Evaluation), Viva-Voce examination will be conducted by the viva-voce board.

### **17.3 Re-registration and Submission of Thesis**

The minimum of 80% attendance requirement for submitting the thesis after re-registration need not be insisted for those students who have fulfilled the minimum academic and residential requirement of three years.

### **17.4 Extension of Time**

17.4.1 Research scholars who do not submit the thesis within the stipulated period should apply for extension of time three months before the completion of three years. Extension of time and the fees to be paid will be considered by the Deans Committee, if the extension is duly recommended by the RAC, Head of the Department, and the Dean of the Faculty, such candidates will be eligible for extension of time for a maximum period of three years.

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

17.4.3 If a scholar requires a few more months after the expiry of the maximum extension period of three years for the submission of the thesis as per the evaluation of the RAC, duly recommended by the Head of the Department and the Dean of the Faculty, as an exceptional case, the Deans committee may consider for re-registration to enable the scholar to submit the thesis. In any case, the time granted shall not exceed six / twelve months.

### **17.5.1 Number of Chances**

17.5.1 A candidate will not be permitted to submit a thesis for the degree on more than two occasions. However, it will be open to the Syndicate, if the Board of Examiners so recommend, to permit the candidate to submit a thesis on a third occasion.

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

## **18. DISCONTINUANCE AND READMISSION**

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

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

18.3 In the case of field experiments or laboratory experiments in which continuity is essential for research and if a student temporarily discontinues in the middle without completing the experiments, then the entire experiment should be repeated, even if the discontinuation period does not exceed two semesters.

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

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### Semester wise Distribution of Credit

Semester	Major Course	Minor Course	Supporting Course	Seminar	Research
I	6	4	2	1	2
II	6	2	3	1	10
III	-	-	-	-	15
IV	-	-	-	-	16
V	-	-	-	-	16
VI	-	-	-	-	16
<b>Total credit</b>	<b>12</b>	<b>6</b>	<b>5</b>	<b>2</b>	<b>75</b>

### Distribution of Courses

Course code	Course Title	Credit hour (Theory + Practical)
<b>Major Courses</b>		<b>12</b>
FSC601*	Innovative Approaches in Fruit Breeding	3+0
FSC602*	Modern Trends in Fruit Production	3+0
FSC603	Recent Developments in Growth Regulation	3+0
FSC605	Arid and Dry Land Fruit Production	2+0
FSC608	Smart Fruit Production	2+0
<b>Minor Course</b>		<b>6</b>
FSC604	Advanced Laboratory Techniques	1+2
FSC606	Abiotic Stress Management in Fruit Crops	2+1
FSC607	Biodiversity and Conservation of Fruit Crops	2+1
<b>Supporting Courses</b>		<b>5</b>
COM 601	Advances in Computer Applications (1+1)	2
STA 601	Advances in Designs of Experiments (2+1)	3
<b>Seminar</b>		
	Doctoral Seminar - I (0+1)	1
	Doctoral Seminar - II (0+1)	1
<b>Research</b>		
	Doctoral Research (0+75)	75
<b>Non credit compulsory courses</b>		
	MOOC (2+0)	-
	Research and Public Ethics (2+0)	-

### Semester wise Distribution of Courses

Sl. No	Courses	Credit Hours
<b>I</b>	<b>First Semester</b>	
1	Major Courses	8
2	Minor courses	3
3	COM 601 Advances in Computer Application	1+1
4	FSC 691 Seminar	0+1
5	FSC 699 Research	0+2
	<b>Total credits</b>	<b>0+16</b>
<b>II</b>	<b>Second Semester</b>	
1	Major Courses	4
2	Minor courses	3
3	STA 601 Advances in Designs of Experiments	2+1
4	FSC 692 Seminar	0+1
5	FSC 699 Research	0+10
	<b>Total credits</b>	<b>0+21</b>
<b>III</b>	<b>Third Semester</b>	
1	Research and Public Ethics*	2+0
2	FSC 699 Research	<b>0+15</b>
<b>IV</b>	<b>Fourth Semester</b>	
1	MOOC*	2+0
2	FSC 699 Research	<b>0+16</b>
<b>V</b>	<b>Fifth Semester</b>	
1	FSC 699 Research	<b>0+16</b>
<b>VI</b>	<b>Sixth Semester</b>	
1	FSC 699 Research	<b>0+16</b>
	<b>Grand total</b>	<b>100</b>

\*Non credit compulsory course.

DEPARTMENT OF HORTICULTURE

Ph.D. Horticulture in Fruit Science

## **PROGRAMME OUTCOME**

**PO 1** - The scholar will acquire knowledge on crop improvement, production technologies, biotechnology and postharvest technologies pertaining to Fruit crops with special reference to advancement in research.

**PO 2** - The scholar will gain skills in approaching research problems and define research methodology for problems solving research in the field of Fruit crops.

**PO 3** - The scholar will be able to do individual research works in Fruits crops.

**PO 4** - The scholar will become eligible to work in research programmes offered by national and international organizations and in teaching Fruit science.

**PO 5** - The scholar will be able to develop expertise in scientific writing and publication of a research outcome.

### **FSC - 601 INNOVATIVE APPROACHES IN FRUIT BREEDING (3+0)**

#### **Learning Objectives**

- To understand the basics and principles of modern plant breeding.

- To equip with information on current breeding objectives in fruit crops.
- To integrate updated information on inherent breeding systems and gene manipulation technologies.
- To update knowledge on current trends and innovative approaches in fruit breeding.
- To design a breeding programme for a given crop species according to specific objectives.

### **Theory**

Current trends and status of fruit breeding - taxonomical status - genetic resources- inheritance patterns - breeding systems -ideotypes- approaches for crop improvement- natural selections- spontaneous mutations -incompatibility systems in fruit crops-rootstock breeding-plant architecture-amenability to mechanization - improvement of quality traits- breeding for biotic and abiotic stress tolerance - fast track breeding- transgenics- marker assisted selection - use of genomics and gene editing technologies - achievements and future thrust in the following fruit crops.

#### **Unit -I: Advances inbreeding of tropical fruit crops - I**

Mango, banana and papaya

#### **Unit -II: Advances inbreeding of tropical fruit crops -II**

Guava, sapota and grapes

#### **Unit -III: Advances inbreeding of sub-tropical fruit crops**

Citrus, pineapple, jack fruit and avocado

#### **Unit -IV: Advances inbreeding of arid fruit crops**

Litchi, annona, ber and pomegranate

#### **Unit -V: Advances inbreeding of temperate fruit and nut crops**

Apple, pear, plum, peach, apricot, strawberry and nut crops

### **Lesson plan**

1. Need and status of fruit breeding in India.
2. Current trends in fruit breeding.
3. Constraints of breeding of fruit crops.
4. Incompatibility systems in fruit crops
5. Methods suggested to overcome the hurdles in breeding.
6. Scope for breeding against production constraints.
7. Genetics of important traits and their inheritance pattern.
8. Plant architecture and amenability to mechanization.
9. Approaches for improvement of fruit quality.
10. Breeding systems in fruit crops.
11. Use of apomixes and wide hybridization.
- 12-13. Molecular and Transgenic approaches in crop improvement.
- 14-15. Marker assisted selection and breeding.
- 16-17. Use of genomics and gene editing technologies.

Taxonomical status - genetic resources - inheritance patterns - ideotypes - approaches for crop improvement - natural selections - spontaneous mutations - rootstock breeding - plant architecture - amenability to mechanization - improvement of quality traits- breeding for biotic and abiotic stress tolerance - transgenics - marker assisted selection - use of genomics and gene editing technologies - achievements and future thrust in the following fruit crops.

18-19. Mango

20-21. Banana

22-23. Papaya

24. Guava

**25. First Test**

- 26-27. Citrus
- 28-29. Grapes
- 30. Sapota
- 31. Pineapple
- 32. Jack
- 33. Avocado
- 34. Litchi
- 35. Annona
- 36. Ber
- 37. Pomegranate
- 38-39. Apple
- 40. Pear
- 41. Plum
- 42. Peach
- 43. Apricot
- 44. Strawberry
- 45. Minor berries
- 46. Walnut
- 47. Almond
- 48-50. Other nut crops

### COURSE OUTCOME

The scholar will be able to

**CO 1**-Understand the current trends in fruit breeding

**CO 2**-Understand the strategies for achieving current breeding objectives

**CO 3**- Understand the innovative approaches for enhancing fruit breeding

**CO 4**-Equip with gene manipulation technologies for enhancing breeding efficiency

**CO 5**-Design breeding programmes for crop specific objectives

**CO - PO Mapping matrix**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>
<b>CO 1</b>	3	3	3	3	2
<b>CO 2</b>	3	2	2	3	<b>2</b>
<b>CO 3</b>	3	2	2	3	3
<b>CO 4</b>	2	2	3	3	3
<b>CO 5</b>	2	3	2	3	3

### References

1. Anil Kumar Shukla, Arun Kumar Shukla and B.B.Vashishtha. 2004. Fruit Breeding Approaches and Achievements. International Book Distributing Company. Charbagh, Lucknow.
2. Al-Khayari, J. Jain, S.N. and Johnson, D.V. 2018. Advances in Plant Breeding Strategies. Vol. 3: Fruits. Springer.
3. Badenes, S. and Byrne, D.H. 2012. Fruit Breeding. Springer.
4. Hancock JF. 2008. Temperate Fruit Crop Breeding: Germplasm to Genomics. Springer.
5. Janick, J and Moore J.N. 1996. Fruit Breeding. Vol. I-III John Wiley & Sons.
6. Kole, C. 2011. Wild Crops Relatives: Genomics and Breeding Resources: Tropical and Subtropical Fruits. Springer-Verlag.
7. Kole C. 2011. Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits. Springer -Verlag.



8. Kole, C. and Abbott, A.G. 2012. Genetics, Genomics and Breeding of Stone fruits. CRC.
9. Orton, T. 2019. Methods in Fruit Breeding. Elsevier.
10. Singh, S.K., Patel, V.B., Goswami, A.K., Prakash, J. and Kumar, C. 2019. Breeding of Perennial Horticultural Crops. Biotech Books. New Delhi.

#### **E-Resources**

1. [www.hort.purdue.edu](http://www.hort.purdue.edu)
2. [www.ishs.org](http://www.ishs.org)
3. [www.iihr.res.in](http://www.iihr.res.in)

### **FSC - 602 MODERN TRENDS IN FRUIT PRODUCTION (3+0)**

#### **Learning Objectives**

- This course is designed to provide students with an in-depth understanding of the principles and practices of fruit crops production.
- Students will learn about the latest developments and trends in the production technologies of fruit crops.
- To provide updated knowledge on modern production systems for enhancing overall fruit productivity.
- To provide in depth understanding of abiotic stresses limiting fruit production.
- To provide updated knowledge on pre and post harvest technologies in fruit crops.

#### **Theory**

National and International scenario in fruit production - commercial varieties - eco physiological requirements - abiotic factors limiting fruit production - recent advances in propagation - rootstock influence - planting systems - high density planting - crop modelling - root zone and canopy management - physiology of flowering, pollination, fruit set and development - integrated and modern approaches in water and nutrient management - fertigation - aspects of crop regulation - role of bio regulators- influence of stress factors - strategies to overcome stress effects - physiological disorders - causes and remedies - maturity indices - harvesting - grading - packing and ripening techniques.

#### **Unit-I: Advanced technologies of tropical fruit crops - I**

Mango, Banana and Guava

#### **Unit-II: Advanced technologies of tropical fruit crops -II**

Citrus, Papaya and Grapes

#### **Unit-III: Advanced technologies of tropical fruit crops -III**

Sapota, Pomegranate, Ber, Aonla and Litchi

#### **Unit-IV: Advanced technologies of sub - tropical fruit crops**

Pineapple, Avocado, Jack fruit, Mangosteen and Fig

#### **Unit-V: Advanced technologies of temperate fruit and nut crops**

Apple, Pear, Peach, Plum, Strawberry, Kiwifruit and Nut crops

#### **Lesson plan**

1. Scope and current status of area, production and export of fruit crops in India.
2. Scope for cultivation and area expansion in fruit crops.
3. Industrial and export potential of fruit crops.

Commercial varieties of regional, National and International importance-eco-physiological requirements- recent trends in propagation- rootstock influence - planting systems- cropping systems- root zone and canopy management - nutrient management- water management- fertigation- role of bio-regulators - abiotic factors limiting fruit production - physiology of flowering - pollination - fruit set and development - honeybees in cross pollination - physiological disorders - causes and remedies- major biotic stresses and their management - quality improvement by management practices - maturity indices - harvesting - grading- packing - storage and ripening techniques-

mechanisation in fruit production - industrial and export potential - Agri. Export Zones (AEZ) and industrial supports for the following crops:

- 4-6. Mango.
- 7-8. Banana
9. Guava
- 10-11. Citrus introduction
12. Acid lime
13. Lemon
14. Oranges
15. Other citrus fruits
16. Papaya
- 17-19. Grapes
- 20-22. Sapota
23. Pomegranate
- 24-25. Ber
- 26-27. Aonla
28. Litchi
- 29-30. Pine apple
31. Avocado
- 32-33. Jack
34. Mangosteen
35. Fig
36. Apple
37. Pear
- 38-40. Peach
41. Plum
42. Straw berry
43. Kiwifruit
44. Apricot
45. Almond
46. Walnut
47. Minor nut crops
48. Cherries
49. Processing industries for fruit crops

### **COURSE OUTCOME**

The student will be able to

**CO 1** - Demonstrate proficiency in the cultural practices and management of sustainable fruit production.

**CO 2** -Recommend suitable production systems for enhancing fruit productivity.

**CO 3** -Develop strategies forovercoming abiotic stresses in fruit production

**CO 4** - Recommend suitable post harvest techniques for fruit crops.

**CO 5** - Manage commercial fruit production units.

### **CO - PO Mapping matrix**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>
<b>CO 1</b>	3	3	3	3	2
<b>CO 2</b>	3	2	3	2	2
<b>CO 3</b>	2	3	2	2	3

CO 4	3	2	2	2	2
CO 5	3	-	-	-	2

### References

1. Bose, T.K., Mitra, S.K. and Sanyal D.2002. Fruits of India – Tropical and Subtropical. 3<sup>rd</sup> Ed. Vol. I, II NayaUdyog.
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3. Chadha, K.L. and Pareek, O.P. (Eds) 1996. Advances in Horticulture. Vol. II - IV. Malhotra Publ. House.
4. Chadha K.L., Ahmed, N., Singh S.K. and Kalia, P. 2016. Temperate Fruits and Nuts-Way Forward for Enhancing Production and Quality. Daya Publishing House, New Delhi
5. Dhillon, W.S. 2013. Fruit Production in India. Narendra Publishing House, New Delhi.
6. Erez, A. 2013. Temperate Fruit Crops in Warm Climates. Springer Science.
7. Jackson, D., Thiele, G., Looney, N.E. and Morley-Bunker, M. 2011. Temperate and Subtropical Fruit Production. CAB International.
8. Robinson, J.C. and Saúco, G. 2010. Bananas and Plantains (Vol. 19). CAB International.
9. Sharma, R.R. and Krishna, H. 2014. Fruit Production: Major Fruits. Daya Publishing House, New Delhi.
10. Singh, S., Shivankar, V.J, Srivastava, A.K. and Singh, I.P. 2004. Advances in Citriculture. Jagminder Book Agency, New Delhi.
11. Tromp, J., Webster, A.S. and Wertheim, S.J. 2005. Fundamentals of Temperate Zone Tree Fruit Production. Backhuys Publishers, Lieden, The Netherlands.

### E-Resources

1. [www.cith.icar.gov.in](http://www.cith.icar.gov.in)
2. [www.cish.res.in](http://www.cish.res.in)
3. [www.iihr.res.in](http://www.iihr.res.in)

## FSC - 603 RECENT DEVELOPMENTS IN GROWTHREGULATION (3+0)

### Learning Objectives

- This course will provide an in depth understanding of growth and developmental processes in plants.
- To impart knowledge on the role of phytohormones and their functions in controlling plant growth and development.
- To understand the developmental process of fruit drop, fruit set and molecular approaches in crop growth regulations.
- To provide latest information on physiological and biochemical aspects of growth and development.
- To develop updates on recent advances in growth regulation of fruit crops.

### Theory

#### Unit -I: Concepts of growth and development

Current concepts and principles-eco-physiological influences on growth and development of fruit crops – flowering- fruit set - crop load and assimilate partitioning and distribution.

#### Unit -II: Plant growth hormones

Phyto-hormones and growth regulators- root and canopy regulation- study of plant growth regulators in fruit culture –structure –biosynthesis - metabolic and morphogenetic effects of different plant growth promoters and growth retardants.

### **Unit-III: Physiology of growth regulation**

Absorption- translocation and degradation of phytohormones - internal and external factors influencing hormonal synthesis- biochemical action- growth promotion and inhibition- canopy management for fertigated orchards.

### **Unit -IV: Growth regulation I**

Regulation of developmental processes -growth regulation aspects of propagation-embryogenesis-seed and bud dormancy-fruit bud initiation- regulation of flowering-off season production.

### **Unit -V Growth regulation II**

Flower drop and thinning- fruit-set and development- fruit drop-parthenocarpy- fruit maturity- ripening and storage- molecular approaches in crop growth regulation-current topics.

### **Lesson plan**

- 1-2. Concepts and principles of eco-physiological influences on growth and development of fruit crops.
3. Assimilate partitioning and distribution in fruit crops.
4. Physiology of flowering.
5. Florigen and anti-florigen concepts with special reference to fruit crops.
6. Floral induction theories and models.
- 7-8. Biosynthesis of auxins, functions and mechanism of action of auxins.
9. Translocation of auxins and physiological role at cellular level.
10. Biosynthesis of gibberellins.
- 11-13. Biosynthesis of gibberellins, functions and mechanism of action of gibberellins.
12. Translocation of gibberellins and physiological role at cellular level.
- 13-15. Biosynthesis of cytokinins, functions and mechanism of action of cytokinins.
16. Translocation of cytokinins and physiological role at cellular level.
- 17-18. Biosynthesis of ethylene, functions and mechanism of action of ethylene.
19. Translocation of ethylene and physiological role at cellular level.
- 20-21. Biosynthesis of brassinosteroids, functions and mechanism of action of brassinosteroids.
22. Translocation of brassinosteroids and physiological role at cellular level.
- 23-24. Biosynthesis of morphactins, functions and mechanism of action of morphactins.
- 25. First Test**
26. Translocation of morphactins and physiological role at cellular level.
27. Biosynthesis of inhibitors and retardants.
28. Mechanism of action of retardants and inhibitors.
29. Translocation of inhibitors and retardants and physiological role at cellular level.
- 30-31. Internal and external factors influencing hormonal synthesis.
32. Role of biostimulants on crop growth and development
33. Canopy management for fertigated orchards.
34. Growth regulations aspects of propagation.
35. Dormancy and their types: exogenous and endogenous dormancy.
36. Biochemistry of seed dormancy.
37. Biochemistry of bud dormancy.
38. Physiology of bud breaking.
39. Methods of overcoming dormancy in fruit crops.
40. Regulation of flowering for off-season production.
41. Concepts of source-sink relationship

- 42-43. Physiology of fruit set and development with special reference to chemical regulation of fruit set.
44. Physiological basis of unfruitfulness.
45. Physiological basis of fruit drop and fruit thinning.
46. Growth and development of parthenocarpic fruits.
47. Physiology of ripening.
- 48-49. Physiological and biochemical basis of senescence.
- 50-51. Molecular approaches in crop growth regulation.

### COURSE OUTCOME

The student will be able to

**CO 1**-gain knowledge on the latest information on physiological and biochemical aspects of growth and development..

**CO 2** -understand the developmental processes of fruit set and molecular approaches in crop growth regulation.

**CO 3**-develop the ability to analyse the growth processes with physiological reasoning.

**CO 4** - understand about the functions of growth hormones in the regulation of growth and development processes.

**CO 5** - gain knowledge about the application of synthetic growth hormones for the manipulation of various physiological processes.

### CO - PO Mapping matrix

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

### References

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2. Buchanan, B., Gruissem, W. and Jones, R. 2002. Biochemistry and Molecular Biology of Plants.
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4. Fosket, D.E. 1994. Plant Growth and Development: A Molecular Approach. Academic Press, USA.
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9. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology. 4<sup>th</sup>Ed. Wadsworth Publication.

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## **FSC - 604 ADVANCED LABORATORY TECHNIQUES (1+2)**

### **Learning objectives**

- To provide an insight into safety measures and laboratory maintenance
- To learn about sampling and standard solutions
- To understand destructive and non-destructive analysis methods
- To learn about chromatograph and microscopic analysis
- To learn about sensory analysis

### **Unit - I: Safety Measures and Laboratory Maintenance**

Safety aspects and upkeep of laboratory - Calibration and standardization of instruments

### **Unit - II: Sampling and standard solutions**

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), textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

### **Unit - III: Destructive and Non-destructive Analysis Methods**

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

### **Unit - IV: Chromatographic and Microscopic Analysis**

Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultrafiltration. 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 - V: 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.

### **Lesson plan**

1. Safety Measures and Laboratory Maintenance
2. Calibration and standardization of instruments
3. Sampling procedures for quantitative analysis
4. Determination of proximate composition of horticultural produce
5. Textural properties of harvested produce
6. TSS, Specific gravity, pH and acidity.
7. Refractometry and Spectrophotometry
8. Non-destructive determination of colour, ascorbic acid, sugars, and starch

### **9. First Test**

10. GC
11. HPLC
12. GCMS
13. Electrophoresis techniques
14. Ultrafiltration
15. Quantitative estimation of rate of ethylene evolution
16. Sensory analysis techniques
17. Control of test rooms

### **Practical**

1. Safety aspects and upkeep of laboratory
2. Calibration and standardization of instruments
3. Sampling procedures for quantitative analysis
4. Determination of moisture
5. Determination of relative water content
6. Determination of physiological loss in weight
7. Determination of total soluble solids
8. Determination of reducing sugars
9. Determination of non - reducing sugars
10. Determination of total sugars
11. Determination of titrable acidity
12. Determination of sugar acid ratio
13. Determination of ascorbic acid
14. Determination of beta carotene
15. Determination of chlorophyll a
16. Determination of chlorophyll b
17. Calibration and standardization of instruments
18. Textural properties of harvested produce
19. Determination of starch index
20. Determination specific gravity
21. Determination pH of fruit
22. Detection of adulterations in fresh fruits
23. Detection of adulterations in processed fruits
24. Non-destructive determination of colour
25. Non-destructive determination of ascorbic acid
26. Non-destructive determination of vitamins
27. Non-destructive determination of carotenoids
28. Non-destructive determination of sugars
29. Non-destructive determination of starch
30. Sensory evaluation
31. Estimation of rate of ethylene evolution using gas chromatograph
32. Use of fluorescent microscope
33. Use of scanning electron microscope
34. Use of phasecontrast microscope

### Course Outcome

The student will be able to

**CO 1-** Learn the safety measures and laboratory maintenance

**CO 2 -** perform sampling and prepare standard solutions

**CO 3 -** perform destructive and non-destructive analysis of samples

**CO 4 -**perform basic chromatographic techniques

**CO 5 -** perform sensory analysis

### CO - PO Mapping matrix

	PO 1	PO 2	PO 3	PO 4	PO 5
<b>CO 1</b>	3	3	3	3	-
<b>CO 2</b>	3	3	3	3	-
<b>CO 3</b>	3	3	3	2	-
<b>CO 4</b>	3	3	2	2	2
<b>CO 5</b>	2	2	2	2	3

## References

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5. Pomrenz Y and Meloan CE. 1996. Food Analysis - Theory and Practice. CBS, USA.
6. Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill, New Delhi.
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## FSC - 605 ARID ZONE AND DRY LAND FRUIT PRODUCTION (2+0)

### Learning objectives

- This course is designed to provide students with an in-depth understanding of the concepts and constraints of arid and dryland regions.
- Students will learn about the latest developments and trends in the production technologies of arid and dry land fruit crops.
- To provide updated knowledge on modern production systems for enhancing overall fruit productivity.
- To provide in depth understanding of abiotic stresses limiting fruit production.
- To provide updated knowledge on stress mitigation for enhancing fruit production. .

### Theory

Characteristic features of arid and dryland regions-distinguishing features of fruit species adapting to the dryland regions -scope and importance- National and International scenario in fruit production-classification of minor fruits -recent advances in propagation - rootstock influence - planting systems - high density planting- cropping systems- training and pruning- crop modelling - precision farming - decision- support systems - aspects of crop regulation - physiological disorders - causes and remedies - physical and chemical regulation - effects on physiology and development - influence of stress factors - strategies to overcome stress effects - integrated and modern approaches in water, and nutrient management-harvesting- post-harvest handling and storage - grading - packing - special production problems and their remedies - total quality management (TQM) of the following crops.

#### Unit- I: Production technology of arid fruit crops I

Aonla,bael, ber and jamun

#### Unit- II: Production technology of arid fruit crops II

Annona, date palm, cactus pear, mahua and khirni

#### Unit-III: Production technology of arid fruit crops III

Karonda, kair, lasoda and monkey jack

#### Unit- IV: Production technology of arid fruit crops IV

Phalsa, pilu, chironji and seabuckthorn

#### Unit- V: Production technology of arid fruit crops V

Rose apple, manila tamarind, West Indian cherry and wood apple.



## Lesson plan

- 1-2. Characteristic features of arid and dryland regions
- 3-4. Distinguishing features of fruit species adapting to the dryland regions
5. Scope and importance- National and International scenario in arid and dryland fruit production.
- 6-8. Constraints and management approaches.
9. Classification of minor fruits.
10. Industrial and export potential of fruit crops.
- 11-12. Climate change and its influence on production pattern of fruit crops.

Recent advances in propagation - rootstock influence - planting systems - high density planting- cropping systems- training and pruning - crop modelling - precision farming- decision- support systems - aspects of crop regulation - physiological disorders - causes and remedies - physical and chemical regulation - effects on physiology and development - influence of stress factors - strategies to overcome stress effects - integrated and modern approaches in water, and nutrient management- harvesting - post-harvest handling and storage - grading - packing - special production problems and their remedies - total quality management (TQM) of the following crops.

- 13-14. Aonla
15. Bael
16. Ber
17. **First Test**
18. Jamun
19. Annona
20. Date palm
21. Cactus pear
22. Mahua
23. Khirni
24. Karonda
25. Kair,
26. Lasoda
27. Monkey jack
28. Phalsa
29. Pilu
30. Chironji
31. Seabuckthorn
32. Rose apple
33. Manila tamarind
34. West Indian cherry
35. Wood apple

## Couse outcome

The student will be able to

**CO 1** - Demonstrate proficiency in the cultural practices and management of sustainable fruit production in the arid and dryland regions..

**CO 2** -to recommend suitable production systems for enhancing fruit productivity.

**CO 3** -to develop strategies for overcoming abiotic stresses in arid fruit production.

**CO 4** - to recommend suitable post harvest techniques for arid fruit crops.

**CO 5** - to manage commercial fruit production units in arid and dryland regions.

## CO-PO Mapping matrix

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

## References

1. Hiwale, S. 2015. Sustainable Horticulture in Semi-arid Drylands. Springer.
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## FSC 606 ABIOTIC STRESS MANAGEMENT IN FRUIT CROPS (2+1)

### Learning Objectives

- This course will provide an in depth understanding of various abiotic stresses
- To comprehend the physiological processes underlying stresses.
- To provide an insight on the impact of stresses on fruit production
- To develop updates on stress mitigation strategies for fruit crops production
- To update knowledge on the recent research trends in the field of abiotic stress management in fruit crops.

### Theory

#### Unit- I: Basic aspects and principles of abiotic stress

Stress – definition – classification- stresses due to water (high and low) - temperature (high and low) - radiation – wind - soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).

#### Unit- II: Mechanisms of stress tolerance

Mechanism and measurements of tolerance to drought- water logging- soil salinity- frost and heat stress in fruit crops- soil – plant-water relations under different stress conditions in fruit crops.

#### Unit- III: Techniques of fruit growing under stress conditions

Classification of fruit crops based on susceptibility and tolerance to various types of stress- influence of root stock in stress alleviation - use of wild species- techniques of

fruit growing under water deficit- water logging- salinity and sodicity - management practices.

#### **Unit- IV: Stress impact and assessment**

Stress assessment -physiology and performance- crop modeling for stress situations- cropping systems- assessing the stress through remote sensing - understanding adaptive features of crops for survival under stress - interaction among different stresses and their impact on crop growth and productivity.

#### **Unit- V: Stress management**

Green-house effect and methane emission and its relevance to abiotic stresses-use of anti transpirants and PGRs in stress management- mode of action and practical use- HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers rain water harvesting - stability and sustainability indices.

#### **Practical**

Identification of susceptibility and tolerance of drought - flood-salinity - sodicity- frost- heat stress - nutrient stress - measurement of tolerance - drought - flood- salinity-frost- heat stress - growing fruit crops under water deficit-salinity and sodicity-use of PGR's and chemicals for alleviation of different stresses.

#### **Lesson plan**

1. Stress - definition and classification.
2. Environmental stress and its types.
3. Drought - toxicity symptoms- mechanisms governing tolerance -physiological and biochemical factors with stress-impact on fruit crops - approaches and advances in management of drought.
4. Flooding - toxicity symptoms- mechanisms governing tolerance -physiological and biochemical factors with stress-impact on fruit crops - approaches and advances in management of flooding.
5. Soil salinity- toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on fruit crops - approaches and advances in management of saline soil.
6. Frost - toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress-impact on fruit crops - approaches and advances in management of frost.
7. Heat stress- toxicity symptoms- mechanisms governing tolerance-physiological and biochemical factors with stress-impact on fruit crops - approaches and advances in management of heat stress.
8. Temperature and Radiation stress-- toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress impact on fruit crops - approaches and advances in management.
9. Nutrient stress and oxidative stress - toxicity symptoms- mechanisms governing tolerance- physiological and biochemical factors with stress impact on fruit crops - approaches and advances in management.
10. Soil-plant-water relations under drought conditions in fruit crops production and their management practices.
11. Soil-plant-water relations under flooded conditions in fruit crops production and their management practices.
12. Soil-plant-water relations under high temperature conditions in fruit crops production and their management practices.

13. Soil-plant-water relations under sodic conditions in fruit crops production and their management practices.
- 14-15. Stress impact on physiology and performance of fruit crops.
16. Classification of fruit crops based on susceptibility and tolerance to various types of stress.

#### 17. First Test

18. Influence of root stock in stress alleviation - use of wild species.
19. Techniques of fruit growing under water deficit conditions.
20. Techniques of fruit growing under water logged conditions.
21. Techniques of fruit growing under saline soil conditions.
22. Techniques of fruit growing under frost conditions.
23. Techniques of fruit growing under heat stress conditions.
24. Assessing the stress situation, cropping system through remote sensing.
25. Adaptive features of fruit crops for survival under stress.
- 26-27. Green house effect and methane emission and its relevance to abiotic stresses.
28. Use of anti-transpirants in stress management.
29. Use of PGRs in stress management.
30. Mode of actions of PGR.
31. Stress management techniques of soil moisture conservation
32. Use of mulches, hydrophilic polymers.
33. Rain water harvesting.
34. Stability and sustainability indices.

#### Practical

1. Identification of susceptibility and tolerance symptoms to drought in fruit crops
2. Identification of susceptibility and tolerance symptoms to flooding in fruit crops
3. Identification of susceptibility and tolerance symptoms to salinity in fruit crops
4. Identification of susceptibility and tolerance symptoms to frost conditions in fruit crops
5. Identification of susceptibility and tolerance symptoms to heat stress in fruit crops
6. Identification of susceptibility and tolerance symptoms to nutrient stress in fruit crops
7. Measurement of tolerance to drought in fruit crops
8. Measurement of tolerance to flooding in fruit crops
9. Measurement of tolerance to salinity in fruit crops
10. Measurement of tolerance to frost condition in fruit crops
11. Measurement of tolerance to heat stress in fruit crops
12. Short term experiments on growing fruit crops under water deficit
13. Short term experiments on growing fruit crops under salinity and sodicity
14. Short term experiments on growing fruit crops under flooding conditions.
15. Use of anti-transpirants for alleviation of stresses
16. Use of PGR's for alleviation of stresses
17. Crop growth sustainability indices.

#### COURSE OUTCOME

The students will be able to

- CO 1-understand the various types of abiotic stresses
- CO 2-comprehend the impact of stress on fruit production
- CO 3 -understand the physiological processes underlying abiotic stresses
- CO 4-update knowledge on management and conservation practices to overcome stress
- CO 5- develop stress mitigation strategies for fruit crops production.

#### CO-PO Mapping matrix

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

## References

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## FSC - 607 BIODIVERSITY AND CONSERVATION OF FRUIT CROPS (2+1)

### Learning Objectives

- To provide an insight on the principles of biodiversity
- To understand the status and magnitude of biodiversity in fruit crops.
- To understand the strategies in germplasm conservation of fruit crops.
- To impart knowledge on IPR in biodiversity and conservation of fruit crops.
- To update knowledge on current status of data base of fruit crops in India.

### Theory

#### Unit - I General aspects

Biodiversity and conservation- issues and goals- needs and challenges - present stat of genecentres-world's major centres of fruit crop domestication-currentstatusofgermplasmavailability/databaseoffruitcropsinIndia.

#### Unit -II Germplasm conservation I

Collection - maintenance and characterization -exploration and collectionofgermplasm-samplingfrequencies-sizeandformsoffruitandnutgermplasm collections-active and base collections.- germplasm conservation- *in situ* and *ex situ* strategies.

#### Unit -III Germplasm conservation II

On farm conservation- problemofrealcitrancy-coldstorageofscions-tissueculture-cryopreservation-pollenandseedstorage- gene banks -role of National institutes in conservation- TBGRI- NBPGR, IIHR, etc. -impact of climate change on biodiversity- Horticultural cropping systems and implication on biodiversity.

#### Unit -IV Regulatory horticulture

Germplasm inventoryand exchange of fruit and nutgermplasm- plant quarantine-phyto-sanitary certification- detection ofgenetic constitution of germplasm and

maintenance of core collection-IPRs-Breeder's rights-Farmer's rights-PPV and FRAct.

### **Unit -V Regulatory horticulture II**

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 fruit varieties in India-

#### **Practical**

Documentation of germplasm- maintenance of passport data and other records of accessions- field exploration trips- exercise on *ex situ* conservation- cold storage-pollen/seed storage- cryopreservation- visits to national gene bank and other centres of PGR activities- core sampling- germplasm characterization using DUS test protocol techniques.

#### **Lesson plan**

1. Bio diversity – introduction, principles
2. Goals and issues in conservation.
3. Genetic diversity- occurrence and distribution.
4. Present status of gene centres.
5. World's major centres of fruit crop domestication.
6. Current status of germplasm availability/ data base of fruit crops in India.
7. Exploration and collection of germplasm
8. Sampling frequencies-size and forms of fruit and nut germplasm collections.
9. Active and base collections
- 10-11. Characterization, documentation and cataloguing of germplasm.
12. Role of National institutes in conservation-TBGRI, NBPGR.etc.
13. Impact of climate change on biodiversity.
14. Horticultural cropping systems and implication on biodiversity
15. Methods of *in situ* conservation of germplasm.
16. Methods for *ex situ* conservation of germplasm
- 17. First Test**
18. Advances and issues in conservation of biodiversity through recalcitrant and orthodox seeds.
- 19-20. Advances and issues in conservation of biodiversity through vegetative propagation-cold storage of scions.
- 21-22. Cryopreservation techniques
23. Pollen and seed storage
24. Germplasm inventory and exchange of fruit and nut germplasm,
25. Material transfer agreement.
26. Plant quarantine protocols-
27. Phyto-sanitary certification
28. Detection of genetic constitution of germplasm and maintenance of core collection.
29. IPRs-Breeder's rights-Farmer's rights. PPV and FRAct.
30. Use of GIS and documentation of local biodiversity.
31. GIS application in horticultural mapping
32. Spatial analyses of field data
33. Benefits of Geographical indications and GI protection
34. GI tagged fruit varieties in India.

#### **Practical schedule**

1. Field exploration trips- exercise in collection and characterization.
2. Visit to field germplasm unit of banana and documentation of germplasm.

3. Visit to field germplasm unit of mango and documentation of germplasm
4. Visit to field germplasm unit of papaya and documentation of germplasm
5. Practices in maintenance of passport data.
6. Practical study of *ex-situ* conservation methods.
7. Practical study of *ex-situ* conservation methods.
8. Methods of seed storage for short and long term conservation.
9. Methods of conservation using vegetative propagules.
10. Study of *in vitro* conservation protocols.
11. Study of species diversity in horticultural cropping systems.
12. Visit to regional germplasm conservation centres.
13. Visit to Gene bank and other centres of PGR activities.
14. Germplasm characterization using DUS test protocol techniques.
15. Use of GIS and documentation of local biodiversity.
16. Study of GIS application in horticultural mapping.
17. Spatial analyses of field data.

### COURSE OUTCOME

The students will be able to

**CO 1** - acquire knowledge on the status of biodiversity of fruit crops.

**CO 2** - gain skill in approaching research problems in the field of biodiversity of fruit crops.

**CO 3** - acquire knowledge on strategies in germplasm conservation of fruit crops

**CO 4** - update knowledge on current status of database of fruit crops in India.

**CO 5** - work in PGR related institutions.

### CO - PO Mapping matrix

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

### References

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## E-Resources

1. [https://www.researchgate.net/publication/338966031\\_A\\_Series-Handbooks\\_of\\_Agro-biodiversity\\_Conservation\\_and\\_Use\\_of\\_Plant\\_Use\\_of\\_Plant\\_Genetic\\_Resources\\_Fruits\\_and\\_Nuts](https://www.researchgate.net/publication/338966031_A_Series-Handbooks_of_Agro-biodiversity_Conservation_and_Use_of_Plant_Use_of_Plant_Genetic_Resources_Fruits_and_Nuts)
2. [https://www.bioversityinternational.org/fileadmin/user\\_upload/online\\_library/publications/pdfs/Conservation\\_and\\_sustainable\\_use\\_of\\_biodiversity\\_of\\_fruit\\_1935.pdf](https://www.bioversityinternational.org/fileadmin/user_upload/online_library/publications/pdfs/Conservation_and_sustainable_use_of_biodiversity_of_fruit_1935.pdf)
3. <https://www.lulu.com/en/us/shop/n-d-polar-/biodiversity-and-conservation-of-fruit-crops/paperback/product-16292n2n.html>

## FSC - 608 SMART FRUIT PRODUCTION (2+0)

### Learning objectives

- To provide an insight into the artificial intelligence in fruit production
- To learn about the crop modelling and forecasting
- To learn about the use of nanotechnology in fruit production
- To learn about the mechanization and automation in fruit production
- To learn about the drones and robotics in fruit production

### Unit - I: Importance and overview of smart fruit production

Introduction and importance- concepts and applications of artificial intelligence systems- case studies in horticulture.

### Unit - II: Crop modelling and forecasting

Application of sensors in fruit production- crop monitoring – crop load and stress incidence forecast modules- remote sensing- Geographical Information System (GIS) - Differential Geo-Positioning System (DGPS) - hi-tech nursery production of fruit crops under protected conditions- ultra modern wireless based drip irrigation network.

### Unit - III: Nanotechnology in fruit growing

Concepts and methods - Nanotechnology for smart nutrient delivery in fruit farming - practical utility-nano-fertilizers-nano-herbicides-nano-pesticides.

### Unit - IV: Mechanization and automation in fruit growing

Production systems amenable to mechanization and automation; automated protected structures (turnkey systems) - hydroponics-aeroponics- bioreactors for large scale plant multiplication.

### Unit - V: Drones and robotics in fruit growing

Concepts and methods - robotic planters- sprayers- shakers- harvesters- stackers, etc.

### Lecture schedule

1. Importance of smart fruit production
2. Concepts of smart fruit production
3. Applications of artificial intelligence
4. Case studies of artificial intelligence in fruit crops-1
5. Case studies of artificial intelligence in fruit crops-2
6. Case studies of artificial intelligence in fruit crops-3
7. Case studies of artificial intelligence in fruit crops-4
8. Case studies of artificial intelligence in fruit crops-5
9. Case studies of artificial intelligence in fruit crops-6
10. Case studies of artificial intelligence in fruit crops-7
11. Application of sensors in fruit production
12. Crop monitoring
13. Remote sensing
14. Geographical Information System
15. Differential Geo-Positioning System
16. Hi-tech nursery



## 17. First Test

18. Ultra modern wireless based drip irrigation network
19. Importance of nanotechnology
20. Nano fertilizers
21. Nano herbicides
22. Nano pesticides
- 23-25. Mechanization in fruit production
24. Automation in fruit production
25. Automated protected structures
26. Hydroponics
27. Aeroponics
28. Bioreactors
29. Drones
30. Robotic planters
31. Sprayers
32. Shakers
33. Harvesters
34. Stackers

### Course Outcome

The student will be able to

CO 1- learn the applications of artificial intelligence in fruit production

CO 2-establish hi-tech nursery for fruit production

CO 3- apply nano particles in fruit protection

CO 4-use drones and robotics in fruit production

CO 5 - establish automated orchards

### CO - PO Mapping matrix

	PO1	PO2	PO3	PO4	PO 5
CO1	3	3	3	3	3
CO2	3	3	3	3	2
CO3	3	3	3	3	3
CO4	3	3	3	2	3
CO5	3	2	2	2	3

### References

1. Chadha et al. 2017. Doubling Farmers Incomes through Horticulture. Daya Publishing House, New Delhi.
2. Chadha et al. 2019. Shaping the Future of Horticulture. Kruger Brentt Publishers, UK.
3. Hewett EW. 2013. Automation, Mechanization and Robotics in Horticulture. In: Workshop on Emerging Postharvest Technologies. UC, Davis, USA.
4. Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
5. Prasad S., Singh D. and Bhardwaj R.L. 2012. Hi-Tech Horticulture. Agrobios (India).
6. Tyagi, S. 2019. Hi- Tech Horticulture. Vols. 1 to 7. NIPA, New Delhi.
7. Zhang Q. 2017. Automation in Tree Fruit production - Principles and Practice. CABI.

### E-Resources

1. <http://horticulture.ucdavis.edu>- Innovative Technology for Horticultural Department.

## COM 601 Advances in computer applications (1+1)

### Objective learning

- After completion of this unit of module, candidate will be able to
- Gain the knowledge about documentation on open source tool.
- To understand the Working knowledge of Latex typesetting language
- Understand features of Python that make it one the most popular languages in the industry.
- Understand the areas where Python is used.

### Theory

#### Unit I Introduction to Latex:

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

#### Unit II Packages and Classes in Latex:

Inserting Equations – Mathematical Symbols – Table of Content – Generating New Command – Figure handling numbering, List of figure, List of Tables.

Packages – Geometry, Hyperref, amsmath, amssymbol – Classes – Article, Book, Report – The BibTex file – Inserting Bibliography – Citing – References.

#### Unit III MS Access:

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

#### Unit IV Introduction to Python:

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

#### Unit V Using Databases in Python:

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

### Lesson plan

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

15. Strings.
16. Python Console.
17. Database in Python.

#### Practicals

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

#### COURSE OUTCOMES

At the end of the course students will be able to

**CO 1:** Problem solving and programming capability.

**CO 2:** Analyse common problems using Latex.

**CO 3:** Learn categories of programs.

**CO 4:** Construct and execute basic programs in Python..

**CO 5:** Use external libraries and packages with Python.

#### CO-PO MAPPING MATRIX

	PO 1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	0	1	3	1	2	2
CO3	0	3	2	3	2	2
CO4	3	0	0	0	3	0
CO 5	0	3	2	0	1	3

#### References

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

#### E-Resources

1. [https://www.overleaf.com/learn/latex/Bibliography\\_management\\_with\\_bibtex](https://www.overleaf.com/learn/latex/Bibliography_management_with_bibtex)
2. [https://en.wikibooks.org/wiki/LaTeX/Bibliography\\_Management](https://en.wikibooks.org/wiki/LaTeX/Bibliography_Management).
3. <https://wiki.python.org/moin/PythonBooks>.
4. <https://devfreebooks.github.io/python/>
5. <https://www.digitalocean.com/community/books/digitalocean-ebook-how-to-code-in-python>.