

AGRICULTURE UNIVERSITY, KOTA

19th MEETING OF ACADEMIC COUNCIL



PROCEEDINGS

Date : 08 April, 2022
Time : 10:30 AM
Venue : Conference Hall,
Agriculture University, Kota

AGRICULTURE UNIVERSITY, KOTA

Minutes of 19th meeting of Academic Council

The 19th meeting of Academic Council of Agriculture University, Kota was held on April 8, 2022 at 10.30 AM in the Conference Hall, Agriculture University, Kota under the Chairmanship of Dr. D.C. Joshi, Vice-Chancellor, AU, Kota. The following members were present:

Name	DESIGNATION	
Dr. Virendra Nepaliya	Rtd. CoE, MPUAT, Udaipur	Member
Dr. I. B. Maurya	Dean, College of Horticulture & Forestry, Jhalawar	Member
Dr. M. C. Jain	Dean, Agriculture College, Kota	Member
Dr N. L. Meena	Dean, Agriculture College, Hindoli	Member
Dr. Pratap Singh	Director Research, AU, Kota	Member
Dr. S. K. Jain	Director Extension Education, AU, Kota	Member
Dr.(Mrs) Mamta Tiwari	Director, HRD, AU, Kota	Member
Dr. Jitendra Singh	Director, Student Welfare, AU, Kota and Professor & Head, Department of Fruit Science, CH&F, Jhalawar	Member
Dr. Mukesh Goyal	Director, PM&E, AU, Kota	Member
Dr. Virendra Singh	Professor & COE, AU, Kota	Member
Dr D K Singh	Professor (Horticulture), KVK, Anta	Member
Dr. S.B.S. Pandey	Associate Professor & Head, Department of Silviculture & Agroforestry, CH&F, Jhalawar	Member
Dr. Baldev Ram	Associate Professor & Head, Department of Agronomy, ARS, Kota	Member
Dr. S.C. Sharma	Associate Professor & Head, Department of Genetics and Plant Breeding, ARS, Kota	Member
Dr. B. L. Dhaka	Associate Professor & Head, Department of Agricultural Extension and Communication, CoA, Kota	Member
Dr. C. B. Meena	Associate Professor & Head, Department of Plant Pathology, CoA, Kota	Member
Dr. M. K. Sharma	Associate Professor & Head, Department of Soil Science and Agriculture Chemistry, CoA, Kota	Member
Dr. B. K. Patidar	Associate Professor & Head, Department of Entomology, CoA, Kota	Member
Dr S C Bhandari	Rtd. CoE, MPUAT, Udaipur	Co-opted Member
Dr S K Sharma	Director Research, MPUAT, Udaipur	Co-opted Member
Dr Manmohan Dobiryal	Professor, Forestry, RLB Central Agriculture University, Jhansi	Co-opted Member
Sh. Ramdhan Raigar	I/c Registrar and Comptroller, AU, Kota	Member
Dr. Ashutosh Mishra	Director Education, AU, Kota	Member Secretary

Dr. R. K. Jain, Ex Principal, AD Patel Institute of Technology, Anand could not attend the meeting. The meeting was started with University *Kulgeet* Dr. Ashutosh Mishra, Director Education and Secretary, Academic Council welcomed Chairman and distinguished members.

The Chairman and Hon'ble Vice-Chancellor in his opening remarks expressed the preparedness of the University for adopting ICAR-BSMA recommendations for Masters and PhD programmes.

Thereafter, the Director Education presented the agenda items one by one. After thorough discussion on each agenda item, following resolutions were made.

Agenda Item No.	Particular				
AUK/AC-19/2022-01/01	Confirmation of the minutes of 18 th meeting of Academic Council held on 04.10.2021 Resolved to confirm				
AUK/AC-19/2022-01/02	Action Taken Report on the proceedings of 18 th meeting of Academic Council held on 04.10.2021 Resolved to approve				
AUK/AC-19/2022-01/03	Approval of Degree nomenclatures of Masters and PhD programmes recommended by ICAR- BSMA As per ICAR- BSMA Committee recommendations, the Degree nomenclatures of Masters and PhD programmes for Faculty of Horticulture & Forestry and Agriculture were approved as below.				
	S.No.	Name of the BSMA Committee	Approved disciplines	Programme	
	1	Plant Sciences	Genetics and Plant Breeding	M.Sc. (Agri.)	Ph.D.
			Seed Science and Technology	M.Sc. (Agri.)	Ph.D.
			Plant Genetic Resources	M.Sc. (Agri.)	Ph.D.
	2	Plant Protection	Entomology	M.Sc. (Agri.)	Ph.D
			Nematology	M.Sc (Agri.)	Ph.D.
			Plant Pathology	M.Sc (Agri.)	Ph.D
	3	Horticultural Sciences	Fruit Science	M.Sc (Hort.)	Ph.D(Hort.)
			Vegetable Science	M.Sc (Hort.)	Ph.D(Hort.)
			Floriculture and Landscaping	M.Sc (Hort.)	Ph.D(Hort.)
			Plantation, Spices, Medicinal & Aromatic Crops	M.Sc (Hort.)	Ph.D(Hort.)
			Postharvest Management	M.Sc (Hort.)	Ph.D(Hort.)
	4	Forestry	Silviculture and Agroforestry	M.Sc. (Forestry)	Ph.D(Forestry)
			Forest Biology and Tree Improvement	M.Sc. (Forestry)	Ph.D(Forestry)
			Forest Products and Utilization	M.Sc. (Forestry)	Ph.D(Forestry)
			Forest Resource Management	M.Sc. (Forestry)	Ph.D(Forestry)
	5	Physical Science	Agricultural Meteorology	M.Sc (Agri.)	Ph.D
			Agronomy	M.Sc (Agri.)	Ph.D
			Soil Science	M.Sc (Agri.)	Ph.D

		Agricultural Physics	M.Sc (Agri.)	Ph.D
		Organic Farming	M.Sc (Agri.)	--
6	Social Sciences	Agri-Business Management	M.Sc. (Agri.)	Ph.D.
		Agricultural Economics	M.Sc. (Agri.)	Ph.D.
		Agricultural Extension Education	M.Sc. (Agri.)	Ph.D.
7	Basic Sciences	Agricultural Chemicals	M.Sc. (Agri.)	Ph.D.
		Biochemistry	M.Sc. (Agri.)	Ph.D.
		Microbiology	M.Sc. (Agri.)	Ph.D.
		Plant Physiology	M.Sc. (Agri.)	Ph.D.
8	Biotechnology & Bioinformatics	Bioinformatics	M.Sc. (Agri.)	Ph.D.
		Molecular Biology & Biotechnology	M.Sc. (Agri.)	Ph.D.
9	Statistical Sciences	Agricultural Statistics	M.Sc. (Agri.)	Ph.D.
		Computer Application	M.Sc. (Agri.)	Ph.D.

Action: DE, AU, Kota

AUK/AC-19/2022-01/04	Approval of Common Academic Regulations for Masters and PhD programmes recommended by BSMA. As per ICAR- BSMA Committee recommendations, the Common Academic Regulations for Masters and PhD programmes for Agriculture University, Kota as appended in Annexure-I were approved with the compulsory incorporation of antiplagiarism for both Masters and PhD programmes of the University. Action: DE, AU, Kota
AUK/AC-19/2022-01/05	Approval of syllabus for Masters and PhD programmes as recommended by ICAR-BSMA As per ICAR- BSMA recommendations, syllabus for Masters and PhD programmes for Agriculture University as appended in Annexure-II were approved from Academic session 2022-23 with core compulsory courses of 12 credits for all the disciplines of Masters and 6 credits for all the disciplines of PhD . Action: DE, AU, Kota
AUK/AC-19/2022-01/06	Approval of revised guidelines for appointment of External Practical Examiners for under graduate programme and payment of remuneration, TA & DA. The Academic Council approved the following guidelines for External Practical Examiners. • The external practical examiners must be appointed by the concern Deans for the constituent colleges. Further, the Deans of constituent colleges will inform to the Controller of Examinations about the appointed practical examiners and the final practical examination schedule. • The Controller of Examinations will appoint the practical examiners for the affiliated colleges.

	• The appointment of practical examiners be done from the faculty available within the AU, Kota. However, if the faculty is not available in a particular subject, may be appointed from outside the university. • The honorarium of checking of answer sheets of practical examiners @ 20/-per answer sheet will be given to the examiners similar to the honorarium of theory answer sheets. • Payment of practical examiners (TA/DA/remuneration for evaluation of answer sheets) will be paid by concerned Deans of the respective constituent Colleges. • The payment of practical examiners (TA/DA/remuneration for evaluation of answer sheets) will be paid by Controller of Examinations for affiliated colleges after receiving the bills of the examiners from the affiliated colleges. • The decisions will be implemented w.e.f. Academic Session 2022-23. Action: COE, AU, Kota
AUK/AC-19/2022-01/07	Approval of improved safety features of degrees/ merit certificates of UG, PG and Ph.D. programmes The improved safety features of degrees/ merit certificates of UG, PG and Ph.D. programmes as below were approved. 1. Media specification and security feature for degree printing: ▪ Size –A4 (210mm x297mm) ▪ Media –Polyester based Non-Tearable and Waterproof media ▪ Micron – 200 ▪ GSM –272 ▪ Density – C- 0.040, M- 0.030 Y - 0.020, K- 0.040 ▪ Opacity – High, no ghost image should appear ▪ Brightness – L- 93, a - 0.2, b - (-) 1.1 2. Security Features: 01 Authentication Light Code 02 Magic Patch 03 Invisible Signatures 04 Rub and disappear patch 05 U.V. fibers in Media. 06 Invisible Ghost Image of the University Logo. 07 Anti-copy feature 08 Alpha numeric QR code 09 Alpha numeric Barcode 10 High resolution border 11 Student U.V. Mark 12 Invisible "Original" mark. 13 Non scannable Student info 14 Anti-Erase 15 Correlation Mark 16 Watermark of University logo 17 Micro/Nano text 18 Transparent University Logo. 19 Invisible security embedded photograph 20 Hidden currency strip. 21 Non-Scannable date and time of printing 22 MICR Font Printing. 23 Holographic University Seal in Hot foil stamping 24 Hidden security in background layer. 25 Holographic Color Logo Action: CoE, AU, Kota

AUK/AC-19/2022-01/08	Approval of revised paper size of PDC and Migration Certificate of UG, PG and Ph.D. programmes The revised PDC and Migration Certificate as appended in Annexure-III was approved Action: CoE, AU, Kota
AUK/AC-19/2022-01/09	Approval of modified language and format of Ph.D. merit certificate Modified language and format of Ph.D. merit certificate as mentioned below was approved Enrolment No..... Photo AGRICULTURE UNIVERSITY, KOTA  CERTIFICATE OF MERIT This is to certify that has been awarded Gold Medal for outstanding academic performance in the Doctor of Philosophy (Horticulture) Fruit Science examination held during year 2020-21. Date..... Rajasthan – 324001, INDIA Controller of Examinations Action: CoE, AU, Kota
AUK/AC-19/2022-01/10	Approval of relaxation in rules for sanctioning 'Study leave' to Sh. Arvind Nagar and Sh. Nirmal Kumar Meena to complete their respective 'Split Ph.D.' program. The matter of relaxation in rules regarding sanctioning EOL/ study leave to Sh. Arvind Nagar and Sh. Nirmal Kumar Meena, as a special case was recommended to BOM for final approval. Action: Registrar, AU, Kota

AUK/AC-19/2022-01/11	Approval to discontinue the admissions in M.Sc. & Ph.D. programmes in Department of Horticulture, COA, Kota and Department of PHT, CHF, Jhalawar from Academic session 2022-23. Admission in Masters and Ph.D. degree programme in the Department of Horticulture under faculty of Agriculture at COA, Kota and PG programme in Department of PHT, CHF, Jhalawar will be suspended w.e.f. academic session 2022-23 was approved. Dean, CoA, Ummedganj/ CHF, Jhalawar
AUK/AC-19/2022-01/12	Approval of panel of examiners for UG/PG core courses for a period of three years. Deffered
AUK/AC-19/2022-01/13	Approval of qualifications for direct recruitment on different teaching cadre posts including SMS in the University. The qualifications/ eligibility for direct recruitment of various teaching posts including SMS in the University appended in Annexure-IV were approved. Action: Registrar, AU, Kota
AUK/AC-19/2022-01/14	Approval of score cards for screening/ short listing of candidates for direct recruitment on different teaching cadre posts including SMS in the University. The score cards for screening/ short listing of candidates for direct recruitment of different teaching cadre posts including SMS in the University as appended in Annexure-V(a,b,c,d) were approved. Action: Registrar, AU, Kota
AUK/AC-19/2022-01/15	Approval of number of candidates to be called for interview for direct recruitment on teaching cadre posts in the University. Resolved to approve that the applications will be shortlisted as per the prescribed score card for each post. The eligible candidates will be called for interview in the ratio of 1:8, i.e. against each post in each category maximum 8 eligible candidates in the order of merit of the score card will be called for the interview. Action: Registrar, AU, Kota
AUK/AC-19/2022-01/16	Approval of the revised eligibility and score cards for personal promotion (under CAS) of teachers from one stage to next higher stage. Resolved to approve as Annexure-VI(a,b,c,d). Action: Registrar, AU, Kota
AUK/AC-19/2022-01/17	Approval of application fee for direct recruitment on teaching cadre posts in the University. Resolved to approve the application fee to be charged from candidates applying for

various teaching cadre posts including SMS under different categories in the University through direct recruitment as indicated below:

Post applied for	Category of applicant		
	UR and BC/ MBC of Creamy layer category	Bona fide candidates of Rajasthan under BC/ MBC (non-creamy layer) and EWS category	Specially abled (Divyangjan), bona fide candidates of Rajasthan under SC and ST category
Professor/ Chief Scientist or equivalent and Associate Professor, Senior Scientist & Head	Rs. 2400/-	Rs. 1800/-	Rs. 1200/-
Assistant Professor, Assistant Librarian, Subject Matter Specialist	Rs. 1600/-	Rs. 1200/-	Rs. 800/-

Action: Registrar, AU, Kota

**AUK/AC-
19/2022-01/18**

Approval of reservation roster for direct recruitment on various teaching and non-teaching cadre posts in the University.

Resolved to approve the reservation rosters as prepared by the roster committee for filling vacant posts in teaching as well as non- teaching cadres in light of the latest rules, regulations and guidelines issued by the state government. (Annexure-VII a & b).

Further, it was also resolved that the discipline wise distribution of teaching cadre posts to be sanctioned for six new Agriculture Colleges under the jurisdiction of AU, Kota namely College of Agriculture, Baran/ Shahbad (Baran)/ Sawaimadhopur/ Barvanda Khurda-Khandar (Sawaimadhopur)/ Karauli/ Todabhim (Karauli) will be the same as earlier notified for the College of Agriculture, Hindoli (Bundi) vide Notification No. F. ()/ AUK/ aca.council/ 2021/ 8263-76 dated 23.09.2021 (Annexure-VIIc) and the reservation roster for the newly sanctioned teaching as well as non- teaching posts to be prepared in continuation of the existing reservation roster will be applicable, as per latest rules, regulations and guidelines issued by the state government.

Action: Registrar, AU, Kota

**AUK/AC-
19/2022-01/19**

Approval of revised guidelines for Award of Best Teacher/ Research Scientist/ Extension Educationist of the University

The revised guidelines for Award of “ Best Teacher /Best Research Scientist/Best Extension Educationist of the University as appended in Annexure-VIII(a,b,c) were approved.

Action: Director,HRD, AU, Kota

**AUK/AC-
19/2022-01/20**

Approval of affiliation of Faculty of Agriculture at Govt. College, Sapotra

An additional faculty namely “Faculty of Agriculture” has been created at Govt. College, Sapotra through the Rajasthan State Finance and Appropriation Bill-

	2021-22, vide sub point No. 380.01 to 380.10. The Department of Higher Education through Department of Agriculture vide letter No. प.8(36)कृषि-3/2021 जयपुर दिनांक 01-02-2022 has approached for the affiliation of the undergraduate academic programme in agriculture at Govt. college Sapotra. The Govt. College, Sapotra, comes under the jurisdiction of the Agriculture University, Kota, therefore, looking to the significance of the above referred budget announcement and the Govt. letters, it is proposed to grant the temporary affiliation of the Faculty of Agriculture, Govt. College, Sapotra with Agriculture University, Kota from the academic session 2022-23. Action: Registrar, AU, Kota																																			
AUK/AC-19/2022-01/21	Approval of starting academic programme at newly sanctioned Colleges of Agriculture under jurisdiction of AU, Kota Recently six new Colleges of Agriculture have been sanctioned by Government of Rajasthan at Karauli, Todabhim (Karauli), Shahbad (Baran), Baran, Sawai Madhopur and Baravanda Khurd-Khandar (Sawai Madhopur) under jurisdiction of Agriculture University, Kota vide letter no. प.1(1) कृषि-3/2022 dated 24.3.2022. These six new COAs will be constituent colleges of Agriculture University, Kota. It is proposed to commence Undergraduate programme leading to the degree of B.Sc. (Hons.) Agriculture with initial annual intake capacity of 30- 60 students depending upon the facilities and resources available. The course structure, semester wise distribution, fee structure, academic rules and regulations etc. will be same as approved by the University for the existing College of Agriculture, Ummedganj, Kota. Action: Registrar, AU, Kota																																			
AUK/AC-19/2022-01/22	Approval of seat matrix for all faculties w.e.f. Academic session 2022-23. The following seat matrix was approved. A.Faculty of Horticulture & Forestry <table><tr><th>Degree Programme</th><th>Total</th><th>N</th><th>P</th><th>ICAR</th></tr><tr><td>Horticulture Faculty</td><td></td><td></td><td></td><td></td></tr><tr><td>B.Sc. (Hons.) Horticulture</td><td>65</td><td>30</td><td>25</td><td>10</td></tr><tr><td>M.Sc. (Hort.) Fruit Science</td><td>05</td><td>4</td><td>-</td><td>1</td></tr><tr><td>M.Sc. (Hort.) Vegetable Science</td><td>05</td><td>4</td><td>-</td><td>1</td></tr><tr><td>M.Sc. (Hort.) Floriculture and Landscaping</td><td>02</td><td>2</td><td>-</td><td>-</td></tr><tr><td>Ph.D. (Hort.) Fruit Science</td><td>03</td><td>1</td><td>1</td><td>1</td></tr></table>	Degree Programme	Total	N	P	ICAR	Horticulture Faculty					B.Sc. (Hons.) Horticulture	65	30	25	10	M.Sc. (Hort.) Fruit Science	05	4	-	1	M.Sc. (Hort.) Vegetable Science	05	4	-	1	M.Sc. (Hort.) Floriculture and Landscaping	02	2	-	-	Ph.D. (Hort.) Fruit Science	03	1	1	1
Degree Programme	Total	N	P	ICAR																																
Horticulture Faculty																																				
B.Sc. (Hons.) Horticulture	65	30	25	10																																
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M.Sc. (Hort.) Vegetable Science	05	4	-	1																																
M.Sc. (Hort.) Floriculture and Landscaping	02	2	-	-																																
Ph.D. (Hort.) Fruit Science	03	1	1	1																																

Forestry Faculty				
B.Sc. (Hons.) Forestry	65	30	25	10
M.Sc. (Forestry) Silviculture and Agroforestry	05	4	-	1
M.Sc. (Forestry) Forest Products and Utilization	05	4	-	1
M.Sc. (Forestry) Forest Biology and Tree Improvement	02	2	-	-
M.Sc. (Forestry) Wildlife Sciences	02	2	-	-
Ph.D. (Forestry) Silviculture and Agroforestry	02	2	-	-

B.Faculty of Agriculture

Degree Programme	COA, Ummedganj Kota			COA, Hindoli		
	Total	N	P	Total	N	P
B.Sc.(Hons.) Ag.	65	40	25	65	40	25
M.Sc.(Ag.) Agronomy	06	04	02		-	-
M.Sc.(Ag.) Genetics & Plant Breeding	06	04	02		-	-
M.Sc. Ag.) Plant Pathology	04	02	02		-	-
M.Sc. (Ag.) Soil Science	04	02	02		-	-
M.Sc. (Ag.) Ext.Edu.& Comm.	04	02	02		-	-
Ph.D. Agronomy	04	03	01		-	-
Ph.D. Genetics & Plant Breeding	03	02	01		-	-

N-Normal seat

P-Payment seat

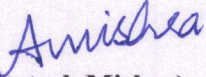
In newly sanctioned six Colleges of Agriculture at Karauli, Todabhim (Karauli), Shahbad (Baran), Baran, Sawai Madhopur and Baravanda Khurd-Khandar (Sawai Madhopur), ratio of normal and payment seat will be 2: 1.

Action:Faculty Chairman-Agriculture/ Horticulture

Table Agenda-1	Table Agenda
	Approval of qualifications/eligibility, scheme of examination and selection criteria for different non-teaching cadre posts in the University. The qualifications/eligibility,scheme of examination and selection criteria for different non-teaching cadre posts in the University as appended in Annexure-IX were approved in principle but looking to the legal aspects, the details be examined by Registrar of the University. Action: Registrar, AU, Kota

After discussing the various agenda items, the remarks were invited from the co-opted members Dr. S C Bhandari, Dr. Virendra Nepaliya Rtd. CoE, MPUAT Udaipur, Dr. S K Sharma, DR, MPUAT, Udaipur and Dr. Manmohan Dobiryal Professor, Forestry, RLB Central Agriculture University, Jhansi.

The meeting ended after extending vote of thanks.



(Ashutosh Mishra)
Director Education



(D. C. Joshi)
Vice Chancellor

Common Academic Regulations for Masters and PhD programmes.

1. Academic Year and Registration

- An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end examination and academic calendar shall be developed by the University from time to time.
- On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified separately. Every enrolled student shall be required to register at the beginning of each semester till the completion of his/her degree programmes.

2. Credit requirements

2.1 Framework of the courses

The following nomenclature and Credit Hrs need to be followed while providing the syllabus for all the disciplines of Masters' and Doctoral Programme.

	Credit Hours	
i. Course work	Masters' Programme	Doctoral Programme
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	-
Seminar	01	02
ii. Thesis Research	30	75
Total	70	100

Major courses: From the Discipline in which a student takes admission.

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments etc.) or necessary for building his/her overall competence

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

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

Supporting Courses

Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS.

CODE	COURSE TITLE	CREDITS
STAT 501	MATHEMATICS FOR APPLIED SCIENCES	2+0
STAT 502	STATISTICAL METHODS FOR APPLIED SCIENCES	3+1
STAT 511	EXPERIMENTAL DESIGNS	2+1
STAT 512	BASIC SAMPLING TECHNIQUES	2+1
STAT 521	APPLIED REGRESSION ANALYSIS	2+1
STAT 522	DATA ANALYSIS USING STATISTICAL PACKAGES	2+1
MCA 501	COMPUTERS FUNDAMENTALS AND PROGRAMMING	2+1
MCA 502	COMPUTER ORGANIZATION AND ARCHITECTURE	2+0
MCA 511	INTRODUCTION TO COMMUNICATION TECHNOLOGIES, COMPUTER NETWORKING AND INTERNET	1+1
MCA 512	INFORMATION TECHNOLOGY IN AGRICULTURE	1+1
BIOCHEM 501	BASIC BIOCHEMISTRY	3+1
BIOCHEM 505	TECHNIQUES IN BIOCHEMISTRY	2+2

2.2 Mandatory requirement of seminars

It has been decided to have mandatory seminars, one in Masters (One Credit) and two in Doctoral programmes (two Credits). The students should be encouraged to make presentations on the latest developments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

3. Residential requirements.

The minimum and maximum duration of residential requirement for Masters' Degree and Ph.D. Programmes shall be as follows:

Degree Programme	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years (4 Semesters)	5 Academic Years (10 Semesters)
Ph. D*	3 Academic Years (6 Semesters)	7 Academic Years (14 Semesters)

***Student may be allowed to discontinue temporarily only after completion of course work**

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits his/her thesis any time during the 4th and 6th semester of his/her residency at the University for Masters' and Ph.D. programme, respectively

4. Evaluation of course work and comprehensive examination

- For M.Sc., multiple levels of evaluation (**First Test, Midterm and Final semester**) is desirable. However, it has been decided that the comprehensive examination **is redundant for M.Sc students**.
- For PhD, the approach should be research oriented rather than exam oriented. In order to provide the student adequate time to concentrate on the research work and complete the degree in stipulated time, the examination **may have to be only semester final**.
- For Ph.D., the comprehensive examination (Pre-qualifying examination) is required. As the students are already tested in course examinations, the **comprehensive examination should be based on oral examination by an external expert** and 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. The successful completion of comprehensive examination is to obtain the "Satisfactory" remark by the external expert.

5. Advisory System

5.1 Advisory Committee

There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree and four in the case of Ph.D. degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the Postgraduate faculty **accredited for appropriate P.G. level research**. However, in those departments **where qualified staff exists** but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of **two years** or more may be included in the Advisory Committee as member representing the **minor**.

At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (including Master's and Ph.D. programmes) for **more than five students**.

The Advisor should convene a meeting of the Advisory Committee at least **once in a Semester**. The summary record should be communicated to the Head of Department, Dean of the College of concerned and Director Education for information.

Advisor/Co-guide/Member, Advisory Committee from other collaborating University/ Institute/ Organization:

- In order to promote quality Post-graduate research and training in cutting edge areas, the University may enter into Memorandum of Understanding

(MOU) with other Universities/Institutions for conducting research. While constituting an Advisory Committee of a student, if the Chairperson, Advisory Committee feels the requirement of involving of a faculty member/scientist of such partnering university /Institute /Organization, he/she may send a proposal to this effect to Director Education along with the proposal for consideration of Student's Advisory Committee (SAC).

- The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/Member, SAC, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution.

Allotment of students to the retiring persons

Normally, **retiring person may not be allotted M. Sc. Student** if he/she is left with less than 2 years of service and Ph.D. student if left with less than 3 years of service. However, in special circumstances, permission may be obtained from the Director Education after due recommendation by the concerned Head of the Department

Changes in the Advisory Committee

- (i) Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be effected with due approval of the Director Education.
- (ii) Normally, staff members of the university on extra ordinary leave or on study leave or who leave the University service will cease to continue to serve as advisors of the Postgraduate students of the University. However, the Director Education may permit them to continue to serve as advisor subject to the following conditions:
 - a) The concerned staff member must be resident in India and if he/she agrees to guide research and must be available for occasional consultations;
 - b) An application is made by the student concerned duly supported by the Advisory Committee;
 - c) In case of a Ph.D. student, he/she must have completed his/her comprehensive examinations and the research work must be well in progress and it is expected that the student will submit the thesis within a year;
 - d) The Head of the Department and the Dean of the College concerned agree to the proposal;
 - e) The staff member, after leaving the University service is granted the status of honorary faculty's membership by the Vice-Chancellor on the recommendation of the Director (Education)/Dean PGS for

guiding as Chairperson or Member, Advisory Committee the thesis/theses of the student(s) concerned only.

- (III) In case the Chairperson/member of a Student's Advisory Committee retires, he/she shall be allowed to continue provided that the student has completed his course work and minimum of 10 research credits and the retiring Chairperson/member stays at the Headquarters of the College, till the thesis is submitted
- (IV) If the Chairperson/member proceeds on deputation to another organization, he/she may be permitted to guide the student provided his/her new organization is at the Headquarters of the College and his/her organization is willing for the same.
- The change shall be communicated to all concerned by the Head of Department.

6. Evaluation of research work

- It is highly desirable for Ph.D. programme and this should be done annually as an essential part of research evaluation. The Student Advisory Committee shall review the progress of research and scrutinize annual progress reports submitted by the student.
- **Midterm evaluation of PhD is a mandatory requirement for all the funding agencies.** Hence, the second review of annual progress report need to be done after completion of two years.

6.1 Prevention of plagiarism

An institutional mechanism should be in place to check the plagiarism. The students of MSc and PhD must be made aware that manipulation of the data/plagiarism is punishable with serious consequences.

7. Learning through online courses

In line with the suggestion in new education policy and the initiatives taken by ICAR and MHRD in the form of e-courses, MOOCs, SWAYAM etc. and also changes taking place globally in respect of learning through online resources it has been agreed to permit the students to enrol for online courses. It is expected that the provision of integrating available online courses with the traditional system of education would provide the students opportunities to improve their employability by imbibing the additional skills and competitive edge.

1. Board of Studies (BoS) of each Faculty shall identify available online courses and a student may select from the listed courses. The interested students may provide the details of the on-line courses to the BoS for its consideration.
2. A Postgraduate student may take up to a maximum of **20% credits** in a semester through online learning resources.

3. The host institute offering the course does the evaluation and provide marks/grades. The BoS shall develop the conversion formula for calculation of GPA and it may do appropriate checks on delivery methods and do additional evaluations, if needed.

8. Internship during Masters programme

Internship for Development of Entrepreneurship in Agriculture (IDEA)

Currently, a provision of 30 credits for dissertation work in Masters programmes helps practically only those students who aspire to pursue their career in academic/ research. There is hardly any opportunity/ provision under this system to enhance the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, **an optional internship/ in-plant training (called as IDEA) in lieu of thesis/ research work is recommended which will give the students an opportunity to have a real time hands-on experience in the industry.** It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhanced partnerships between academia and industry.

The main objectives of the programme:

1. To promote the linkages between academia and industry
2. To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization
3. Collaboration between Universities and industries through pilot projects
4. To develop methods for knowledge transfer, innovation and networking potential
5. To enhance skill, career development and employability

Following criteria for IDEA will be taken into consideration:

- At any point of time there will **not be more than 50% of students** who can opt under IDEA.
- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry
- Total credits (30) will be **divided into 20 for internship/ in-plant training and 10 for writing** the report followed by viva-voce similar to dissertation.
- Work place will be industry; however, academic/research support would be provided by the University or both. MoU may be developed accordingly.
- The IPR, if any, would be as per the University policy.

9. Teaching Assistantship

- Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters. This is an important part of

PhD training all over the world and it is expected to address the shortage of faculty in many institutions/universities. The fulltime doctoral students of the University **with or without fellowship** may be considered for award of Teaching Assistantships in their respective Departments. The Teaching Assistantship shall be offered only to those doctoral students **who have successfully finished their course work**. Any consideration for award of Teaching Assistantships must have the consent of the supervisor concerned.

Teaching Assistantships shall be awarded on semester to semester basis on the recommendation of a screening/ selection committee to be constituted by the Vice Chancellor. All classes and assignments given to the Teaching Assistants, including tutorials, practicals and evaluation work shall be under the supervision of a faculty member who would have otherwise handled the course/ assignment.

- Each Ph.D. student may be allowed to take a maximum of **16 classes** in a month to UG/Masters students.
- **No additional remuneration shall be paid to the students who are awarded ICAR JRF/SRF.** The amount of fellowship to be paid as remuneration to other students (who are receiving any other fellowship or without any fellowships) may be decided by the concerned universities as per the rules in force. However, the total amount of remuneration/ and fellowship shall not exceed the amount being paid as JRF/SRF of ICAR.
- At the end of each term, Teaching Assistants shall be given a certificate by the concerned Head of the Department, countersigned by the Dean, specifying the nature and load of assignments completed.

10.Registration of project personnel (SRF/RA) for PhD

A provision may be made to enable the project personnel (SRF/RA) to register for PhD. However, this can be done only if they are selected based on some selection process such as walk-in-interview. The prior approval of PI of the project is mandatory to consider the application of project personnel (SRF/RA) for PhD admission. The candidates need to submit the declaration stating that the project work shall not be compromised because of PhD programme. Further, in order to justify the project work and Ph.D. programme, the number of course **credits should not be more than 8 in a semester** for the project personnel (SRF/RA) who intend to register for Ph.D.

11.Compliance with the National Education Policy-2020

While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:

- Given the 21st century requirements, quality higher education must aim to

develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and 21st century capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020)

At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020)

- Flexibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020)
- As part of a holistic education, students at all HEIs will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).
- HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centres; centres in frontier areas of research; greater industry academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).
- Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High quality pedagogy is then necessary to successfully impart the curricular

material to students; pedagogical practices determine the learning experiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

12. Definitions of academic terms

Chairperson means a teacher of the major discipline proposed by the Head of Department through the Dean of the College and duly approved by the Director of Education/Dean Post Graduate Studies (or as per the procedure laid down in the concerned University regulations) to act as the Chairperson of the Advisory Committee and also to guide the student on academic issues.

Course means a unit of instruction in a discipline carrying a specific number and credits to be covered in a semester as laid down in detail in the syllabus of a degree programme.

Credit means the unit of work load per week for a particular course in theory and or practical. One credit of theory means one class of one clock hour duration and one credit practical means one class of minimum two clock hours of laboratory work per week.

Credit load of a student refers to the total number of credits of all the courses he/she registers during a particular semester.

Grade point (GP) of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, expressed and rounded off to second decimal place.

Credit point (CP) refers to the Grade Point multiplied by the number of credits of the course, expressed and rounded off to second decimal place.

Grade point average (GPA) means the total credit point earned by a student divided by total number of credits of all the courses registered in a semester, expressed and rounded off to second decimal place.

Cumulative Grade Point Average (CGPA) means the total credit points earned by a student divided by the total number of credits registered by the student until the end of a semester (all completed semesters), expressed and rounded off to second decimal place.

Overall Grade Point Average (OGPA) means the total credit points earned by a student in the entire degree program divided by the total number of credits required for the P.G. degree, expressed and rounded off to second decimal place.

Faculty of Horticulture and Forestry

The approved courses programme for M.Sc. and Ph.D. of various departments have been arranged in following manner:

Nomenclature of degree programme:

S. No.	Discipline/Departments	Nomenclature of Degree Programme		Hindi Name
		M.Sc.	Ph.D.	
1.	Fruit Science	M.Sc. (Hort.) Fruit Science	Ph.D. (Hort.) Fruit Science	फल विज्ञान
2.	Vegetable Science	M.Sc. (Hort.) Vegetable Science	Ph.D. (Hort.) Vegetable Science	सब्जी विज्ञान
3.	Floriculture and Landscaping	M.Sc. (Hort.) Floriculture and Landscaping	Ph.D. (Hort.) Floriculture and Landscaping	पुष्प एवं भूदृष्य विज्ञान
4.	Post Harvest Management	M.Sc. (Hort.) Postharvest Management	Ph.D. (Hort.) Postharvest Management	शस्योत्तर प्रबंधन
5.	Silviculture and Agroforestry	M.Sc. (Forestry) Silviculture and Agroforestry	Ph.D. (Forestry) Silviculture and Agroforestry	वन संवर्धन एवं कृषि वानिकी
6.	Forest Products and Utilization	M.Sc. (Forestry) Forest Products and Utilization	Ph.D. (Forestry) Forest Products and Utilization	वनोत्पाद एवं उपयोग
7.	Forest Biology and Tree Improvement	M.Sc. (Forestry) Forest Biology and Tree Improvement	Ph.D. (Forestry) Forest Biology and Tree Improvement	वन जैविक एवं वृक्ष सुधार

• **M.Sc. (Hort.) Fruit Science**

Major courses

Course Code	Course Title	Cr Hrs
	Semester I	
FSC-511*	Tropical Fruit Production	2+1
FSC-512*	Propagation and Nursery Management of Fruit Crops	2+1
FSC-513	Systematics of Fruit Crops	2+1
FSC-514	Organic Fruit Culture	2+1
	Semester II	
FSC-521*	Sub-Tropical and Temperate Fruit Production	2+1
FSC-522*	Breeding of Fruit Crops	2+1
FSC-523	Minor Fruit Production	2+1
FSC-524	Canopy Management in Fruit Crops	1+1
FSC-525	Export Oriented Fruit Production	2+1
	Semester III	
FSC-531	Growth and Development of Fruit Crops	2+1
FSC-532	Nutrition of Fruit Crops	2+1
FSC-533	Biotechnology of Fruit Crops	2+1
FSC-534	Climate Change and Fruit Crops	1+0
	Semester IV	
FSC-591	Seminar	0+1
FSC-599	Research	0+30

* **Core and compulsory courses.**

Note: A student has to opt total 20 credit hours.

Syllabus of Major courses of Fruit Science

FSC-511 TROPICAL FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

Unit I: Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco- physiological requirements.

Block 2: Agro - Techniques

Unit I: Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio- fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders - causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

CROPS

Mango, Banana, Guava, Pineapple, Papaya, Avocado, Jackfruit, Annonas, Aonla and Ber

PRACTICALS

- Distinguished features of tropical fruit species, cultivars and rootstocks (2)
- Demonstration of planting systems, training and pruning (3)
- Hands on practices on pollination and crop regulation (2)
- Leaf sampling and nutrient analysis (3)
- Physiological disorders-malady diagnosis (1)
- Physico-chemical analysis of fruit quality attributes (3)
- Field/Exposure visits to tropical orchards (1)
- Project preparation for establishing commercial orchards (1)

RESOURCES

Bartholomew, D.P., Paull, R.E. and Rohrbach, K.G. 2002. *The Pineapple: Botany, Production, and Uses*. CAB International.

Bose, T, K., Mitra, S.K. and Sanyal, D., 2002. *Fruits of India – Tropical and Sub-Tropical*. 3rd Edn. Naya Udyog, Kolkata.

Dhillon, W.S., 2013. *Fruit Production in India*. Narendra Publ. House, New Delhi.

Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits: Principles and Practices*. IBDC Publishers, New Delhi.

Litz, R.E. 2009. *The Mango : Botany, Production and Uses*. CAB International.

Madhawa Rao, V. N. 2013. *Banana*. ICAR, New Delhi.

Midmore, D. 2015. *Principles of Tropical Horticulture*. CAB International. Mitra, S. K. and Sanyal, D. 2013. *Guava*, ICAR, New Delhi.

Morton, J F. 2013. *Fruits of Warm Climates*. Echo Point Book Media, USA.

Nakasome, H. Y and Paull, R. E. 1998. *Tropical Fruits*. CAB International. Paull, R.E.

and Duarte, O., 2011. *Tropical Fruits* (Vol. 1). CAB International.

Rani, S., Sharma, A. and Wali, V. K. 2018. *Guava (Psidium guajava L.)*. Astral, New Delhi. Robinson, J.C. and Saúco, V.G. 2010. *Bananas and Plantains*. CAB International.

Sandhu, S. and Gill, B.S. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi Schaffer, B., Wolstenholme, B. N. and Whiley, A. W. 2013. *The Avocado: Botany, Production and Uses*. CAB International

Sharma, K. K. and Singh, N. P. 2011. *Soil and Orchard Management*. Daya Publishing House, New Delhi.

Valavi, S.G., Peter, K.V. and Thottappilly, G., 2011. *The Jackfruit*. Stadium Press, USA.

FSC-512 PROPAGATION AND NURSERY MANAGEMENT IN FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

Unit 1: General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing.

Block 2: Propagation

Unit I: Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship - graft incompatibility, physiology of rootstock and top working.

Unit II: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.

Block 3: Nursery

Unit I: Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.

PRACTICAL

- Hands on practices on rooting of dormant and summer cuttings (3)
- Anatomical studies in rooting of cutting and graft union(1)
- Hands on practices on various methods of budding and grafting (4)
- Propagation by layering and stooling (2)
- Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening (4)
- Visit to commercial tissue culture laboratories and accredited nurseries (2)

RESOURCES

- Bose, T. K., Mitra, S. K. and Sadhu, M.K., 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkatta.
- Davies, F.T., Geneve, R.L. and Wilson, S.B. 2018. *Hartmann and Kester's Plant Propagation- Principles and Practices*. Pearson, USA/PrenticeHall of India. New Delhi.
- Gill, S. S., Bal, J. S. and Sandhu, A. S. 2016. *Raising Fruit Nursery*. Kalyani Publishers, New Delhi.
- Jain, S. and Ishil, K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.
- Jain, S. and Hoggmann, H. 2007. *Protocols for Micropropagation of Woody Trees and Fruits*. Springer.
- Joshi, P. 2015. *Nursery Management of Fruit Crops in India*. NIPA, New Delhi.
- Love et al. 2017. *Tropical Fruit Tree Propagation Guide*. UH-CTAHR F_N_49. College of Tropical Agriculture and Human Resources University of Hawaii at Manoa, USA.
- Peter, K.V., eds., 2008. *Basics of Horticulture*. New India Publishing Agency, New Delhi.
- Rajan, S. and Baby, L.M., 2007. *Propagation of Horticultural Crops*. NIPA, New Delhi.
- Sharma, R.R., 2014. *Propagation of Horticultural Crops*. Kalyani Publishers, New Delhi.
- Sharma, R.R. and Srivastav, M., 2004. *Propagation and Nursery Management*. Intl. Book Publishing Co., Lucknow.
- Singh, S. P. 1989. *Mist Propagation*. Metropolitan Book Co.
- Singh, R. S. 2014. *Propagation of Horticultural Plants : Arid and Semi-Arid Regions*. NIPA, New Delhi.
- Tyagi, S. 2019. *Hi-Tech Horticulture. Vol I: Crop Improvement, Nursery and Rootstock Management*. NIPA, New Delhi

FSC-513 SYSTEMATICS OF FRUIT CROPS (2+1)

THEORY

Block 1: Biosystematics

UNIT I: Nomenclature and Classification: Biosystematics – introduction and significance ; history of nomenclature of cultivated plants, classification and nomenclature systems ; International code of nomenclature for cultivated plants

Block 2: Botanical Keys and Descriptors

UNIT I: Identification and Description: Methods of identification and description of cultivated fruit and nut species and their wild relatives features ; development of plant keys for systematic identification and classification.

Development of fruit crop descriptors- based upon Bioversity International Descriptors and UPOV/DUS test guidelines, botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops

Block 3: Special Topics

UNIT I: Registration and Modern Systematics: Registration, Use of chemotaxonomy, biochemical and molecular markers in modern systematics

PRACTICALS

1. Exercises on identification and pomological description of various fruit species and cultivars(6)
2. Development of descriptive blanks *vis-a-vis* UPOV/DUS test guidelines and Bioversity International(4)
3. Descriptors for developing fruit species and cultivar descriptive databases(4)
4. Visits to major germplasm centres and field genebanks (2)

RESOURCES

ASHS, 1997. *The Brooks & Olmo Register of Fruit and Nut Varieties*. 3rd Ed. ASHS Press. Bhattacharya, B. and Johri, B.M. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Pub. House, New Delhi.

Pandey, B.P. 1999. *Taxonomy of Angiosperms*. S. Chand & Co. New Delhi.

Pareek, O.P. and Sharma, S., 2017. *Systematic Pomology*. Scientific Publishers, Jodhpur.

Sharma, G., Sharma, O.C. and Thakur, B.S. 2009. *Systematics of Fruit Crops*. NIPA, N. Delhi.

Simpson, M. 2010. *Plant Systematics*. 2nd Edn. Elsevier.

Spencer, R.R. Cross, R. and Lumley, P. 2003. *Plant Names*. 3rd Ed. A Guide to Botanical Nomenclature, CISRO, Australia.

Srivastava, U, Mahajan, R.K., Gangopadhyay, K.K., Singh, M. and Dhillon, B.S. 2001. *Minimal Descriptors of Agri-Horticultural Crops. I: Fruits*. NBPGR, New Delhi.

Zielinski, Q. B. 1955. *Modern Systematic Pomology*. Wm. C. Brown Co., Iowa, USA.

FSC-514 ORGANIC FRUIT CULTURE (2+1)

THEORY

Block 1: General Aspects

UNIT I: Principles and Current Scenario: Organic horticulture, scope, area, production and world trade, definition, principles, methods and SWOT analysis.

Block 2: Organic Culture

UNIT I: Farming System and Practices: Organic farming systems including biodynamic farming, natural farming, homa organic farming, rishi krishi, EM technology, cosmic farming; on-farm and off-farm production of organic inputs, role of bio-fertilizers, bio enhancers, legumes, inter cropping, cover crops, green manuring, zero tillage, mulching and their role in organic nutrition management. Organic seeds and planting materials, soil health management in organic production, weed management practices in organic farming, biological management of pests and diseases, trap crops, quality improvement in organic production of fruit crops.

Block 3: Certification

UNIT I: Inspection, Control Measures and Certification: Inspection and certification of organic produce, participatory guarantee system (PGS), NPOP, documentation and control, development of internal control system (ICS), Concept of group certification, constitution of grower group as per NPOP, preparation of ICS manual, internal and external inspection, concept of third party verification, certification of small farmer groups (Group Certification), transaction certificate, group certificate, critical control points (CCP) and HACCP, IFOAM guidelines on certification scope and chain of custody, certification trademark – The Logo, accredited certification bodies under NPOP. Constraints in certification, IFOAM and global scenario of organic movement, postharvest management of organic produce. Economics of organic fruit production

PRACTICALS

1. Design of organic orchards/farms management(1)
2. Conversion plan(1)
3. Nutrient management and microbial assessment of composts and bio-enhancers(2)
4. Preparation and application of composts, bio-enhancers and bio-pesticides(2)
5. Organic nursery raising (1)
6. Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, green manure, cover, mulching (2)
7. Preparation and use of neem based products(1)
8. Biodynamic preparations and their role in organic agriculture, EM technology and products, biological/natural management of pests and diseases(2)
9. Soil solarisation (1)
10. Frame work for GAP(1)
11. Documentation for certification(1)

RESOURCES

Claude, A. 2004. *The Organic Farming Sourcebook*. Other India Press, Mapusa, Goa, India. Dabholkar, S.A. 2001. *Plenty for All*. Mehta Publishing House, Pune, Maharashtra.

Das, H.C. and Yadav, A. K. 2018. *Advances in Organic Production of Fruit Crops*. Westville Publishing House, New Delhi.

Deshpande, M.S. 2003. *Organic Farming with respect to Cosmic Farming*. Mrs. Pushpa Mohan Deshpandey, Kolhapur, Maharashtra.

Deshpande, W. R. 2009. *Basics of Organic Farming*. All India Biodynamic and Organic Farming Association, Indore. M.P.

Gaur, A.C., Neblakantan, S. and Dargan, K.S. 1984 *Organic Manures*. ICAR., New Delhi Lampkin, N. and Ipswich, S. 1990. *Organic Farming*. Farming Press. London, UK.

Lind, K., Lafer, G., Schloffer, K., Innershofer, G. And Meister, H. 2003. *Organic Fruit Growing*. CAB International

Palaniappan, S.P. and Annadurai, K. 2008. *Organic Farming- Theory and Practice*. Scientific Publishers, Jodhpur, Rajasthan, India.

Palekar, S. 2004. *The Technique of Spritual Farming*. Chandra Smaritee, Sai Nagar, Amrawati, Maharashtra.

Proctor, P. 2008. *Biodynamic Farming and Gardening*. Other India Press, Mapusa, Goa. Ram, R.A. and Pathak, R.K. 2017. *Bioenhancers*. Lap Lambert Academic Publishing, A.P.

FSC-521 SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

Unit I: Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, eco- physiological requirements.

Block 2: Agro - Techniques

Unit I: Propagation, Planting and Orchard Floor Management: Propagation, planting systems and densities, training and pruning, rejuvenation and replanting, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders- causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

CROPS

Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond and Pecan

PRACTICALS

1. Distinguished features of fruit species, cultivars and rootstocks (2)
2. Demonstration of planting systems, training and pruning (3)
3. Hands on practices on pollination and crop regulation (2)
4. Leaf sampling and nutrient analysis (3)
5. Physiological disorders-malady diagnosis (1)
6. Physico-chemical analysis of fruit quality attributes (3)
7. Field/Exposure visits to subtropical and temperate orchards (1)
8. Project preparation for establishing commercial orchards (1)

RESOURCES

- Chadha, K.L. and Awasthi, R.P. 2005. *The Apple*. Malhotra Publishing House, New Delhi. Chadha, T.R. 2011. *A Text Book of Temperate Fruits*. ICAR, New Delhi
- Childers, N. F., Morris, J. R. and Sibbett, G. S. 1995. *Modern Fruit Science : Orchard and Small Fruit Culture*. Horticultural Publications, USA.
- Creasy, G and Creasy L. 2018. *Grapes*. CAB International. Davies, F.S. and Albrigo, L.G., 1994. *Citrus*. CAB International.
- Dhillon, W.S., 2013. *Fruit Production in India*. Narendra Publishing House, New Delhi. Jackson, D., Thiele, G., Looney, N. E. and Morley-Bunker, M. 2011. *Temperate and Subtropical Fruit Production*. CAB International.
- Ladanyia, M., 2010. *Citrus Fruit : Biology, Technology and Evaluation*. Academic Press. Layne, D.R. and Bassi, D. 2008. *The Peach: Botany, Production and Uses*. CABI.
- Menzel, C. M. and Waite, G. K. 2005. *Litchi and Longan: Botany, Production and Uses*. CAB International.
- Pandey, R. M. and Randey, S. N. 1996. *The Grape in India*. ICAR, New Delhi. Rajput, C.B.S. and Haribabu, R.S. 2006. *Citriculture*, Kalyani Publishers, New Delhi.
- Sandhu, S. and Gill, B. S. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi. Sharma, R. M., Pandey, S. N. and Pandey, V. 2015. *The Pear - Production, Post-harvest Management and Protection*. IBDC Publisher, New Delhi.
- Sharma, R. R. and Krishna, H., 2018. *Textbook of Temperate Fruits*. CBS Publishers and Distributors Pvt. Ltd., New Delhi.
- Singh, S., Shivshankar, V. J, Srivastava, A. K. and Singh I. P. 2004. *Advances in Citriculture*. NIPA, New Delhi.
- Tromp, J., Webster, A. S. and Wertheim, S. J. 2005. *Fundamentals of Temperate Zone Tree Fruit Production*. Backhuys Publishers, Lieden, The Netherlands.\
- Webster, A. and Looney, N. *Cherries : Crop Physiology, Production and Uses*. CABI. Westwood, M. N. 2009. *Temperate Zone Pomology: Physiology & Culture*. Timber Press, USA.

FSC-522 BREEDING OF FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

Unit I: Importance, Taxonomy and Genetic Resources: Introduction and importance, origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources.

Block 2: Reproductive Biology

Unit I: Blossom Biology and Breeding Systems: Blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.

Block 3: Breeding Approaches

Unit I: Conventional and Non-Conventional Breeding: Approaches for crop improvement – direct introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrusts.

CROPS

Mango, Banana, Pineapple, Citrus, Grapes, Litchi, Guava, Pomegranate, Papaya, Apple, Pear, Plum, Peach, Apricot, Cherries, Strawberry, Kiwifruit, Nuts

PRACTICAL

- Exercises on bearing habit, floral biology(2)
- Pollen viability and fertility studies(1)
- Hands on practices in hybridization(3)
- Raising and handling of hybrid progenies(2)
- Induction of mutations and polyploidy(2)
- Evaluation of biometrical traits and quality traits(2)
- Screening for resistance against abiotic stresses (2)
- Developing breeding programme for specific traits (2)
- Visit to research stations working on fruit breeding (1)

RESOURCES

Abraham, Z. 2017. *Fruit Breeding*. Agri-Horti Press, New Delhi.

Badenes, M. L. and Byrne, D. H. 2012. *Fruit Breeding*. Springer Science, New York. Dinesh, M. R. 2015. *Fruit Breeding*, New India Publishing Agency, New Delhi.

Ghosh, S. N. Verma, M. K. and Thakur, A. 2018. *Temperate Fruit Crop Breeding-Domestication to Cultivar Development*. NIPA, New Delhi.

Hancock, J. F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer Science, New York.

Jain, S. N. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: Tropical Species*. Springer Science, New York.

Jain, S. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: Temperate Species*. Springer Science, New York.

Janick, J. and Moore, J. N. 1996. *Fruit Breeding*. Vols. I - III. John Wiley & Sons, USA. Kumar, N.

2014. *Breeding of Horticultural Crops: Principles & Practices*. NIPA, N. Delhi. Moore, J. N. and Janick,

J. 1983. *Methods in Fruit Breeding*. Purdue University Press, USA. Ray, P. K. 2002. *Breeding Tropical and Subtropical Fruits*. Narosa Publ. House, New Delhi.

FSC-523 MINOR FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

UNIT I: Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands.

Block 2: Agro-Techniques

UNIT I: Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality.

Block 3: Marketing and Utilization

UNIT I: Post-Harvest Management: Post harvest management, marketing ; minor fruit crops in terms of medicinal and antioxidant values ; their uses for edible purpose and in processing industry

CROPS:

Bael, chironji, fig, passionfruit, jamun, phalsa, karonda, woodapple, Cactus pear, khejri, kair, pilu, lasoda, loquat, tamarind, dragon fruit, monkey jack, mahua, khirni, amra, kokum, cape gooseberry, kaphal, persimmon, pistachio, seabuckthorn, hazel nut and Other minor fruits of regional importance

PRACTICALS

- Visits to institutes located in the hot and cold arid regions of the country(2)
- Identification of minor fruits plants/cultivars(2)
- Collection of leaves and preparation of herbarium(1)
- Allelopathic studies(2)
- Generating know-how on reproductive biology of minor fruits(4)
- Fruit quality attributes and biochemical analysis(3)
- Project formulation for establishing commercial orchards in fragile ecosystems(1)

RESOURCES

Ghosh, S. N., Singh, A. and Thakur, A. 2017. *Underutilized Fruit Crops: Importance and Cultivation*. Jaya Publication House, New Delhi.

Krishna, H. and Sharma, R.R., 2017. *Fruit Production :Minor Fruits*.Daya Publishing House, New Delhi

Mazumdar, B. C. 2014. *Minor Fruit Crops of India: Tropical and Subtropical*. Daya Publication House, New Delhi

Nath, V., Kumar, D., Pandey, V. and Pandey, D., 2008. *Fruits for the Future*. Satish Serial Publishing House, New Delhi.

Pareek, O. P., Sharma, S. and Arora, R. K., 2007. *Underutilised Edible Fruits and Nuts*, IPGRI, Rome.

Peter, K.V., 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi.

Rana, J. C. and Verma, V. D. 2011. *Genetic Resources of Temperate Minor Fruit (Indigenous and Exotic)*. NBPGR, New Delhi.

Saroj, P. L. and Awasthi, O. P., 2005. *Advances in Arid Horticulture*, Vol. II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.

Saroj, P. L., Dhandar, D. G. and Vashishta, B.B. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow.

Singh *et al.*, 2011. *Jamun*. ICAR, New Delhi.

FSC-524 CANOPY MANAGEMENT OF FRUIT CROPS (1+1)

THEORY

Block 1: Canopy Architecture

UNIT I: Introduction, Types and Classification: Canopy management - importance and factors affecting canopy development. Canopy types and structures, canopy manipulation for optimum utilization of light and its interception. Spacing and utilization of land area - Canopy classification.

Block 2: Canopy Management

UNIT I: Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion. Canopy management through plant growth regulators, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality.

PRACTICALS

1. Study of different types of canopies (2)
2. Training of plants for different canopy types(2)
3. Canopy development through pruning (2)
4. Understanding bearing behaviour and canopy management in different fruits(2)
5. Use of plant growth regulators(2)
6. Geometry of planting(1)
7. Development of effective canopy with support system(2)
8. Study on effect of different canopy types on production and quality of fruits(2)

RESOURCES

- Bakshi, J.C.,Uppal, D.K. and Khajuria, H.N. 1988. *The Pruning of Fruit Trees and Vines*. Kalyani Publishers, New Delhi.
- Chadha, K. L. and Shikhamany, S. D., 1999. *The Grape, Improvement, Production and Post Harvest Management*. Malhotra Publishing House, Delhi.
- Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits: Principles and Practices*. IBDC Publishers, New Delhi.
- Pradeepkumar, T. 2008. *Management of Horticultural Crops*. NIPA, New Delhi.
- Singh, G. 2010. *Practical Manual on Canopy Management in Fruit Crops*. Dept. of Agriculture and Co-operation ,Ministry of Agriculture (Gol), New Delhi.
- Srivastava, K. K., 2012. *Canopy Management in Fruits*. ICAR, New Delhi

FSC-525 EXPORT ORIENTED FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

UNIT I: Statistics and World Trade: National and international fruit export and import scenario and trends ; Statistics and India's position and potentiality in world trade ; export promotion zones in India. Government Policies.

Block 2: Regulations

UNIT I: Policies, Norms and Standards: Scope, produce specifications, quality and safety standards for export of fruits viz., mango, banana, grape, litchi, pomegranate, walnut, apple and other important fruits. Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

Block 3: Quality Assurance

UNIT I: Infrastructure and Plant Material: Quality fruit production under protected environment; different types of structures – Automated greenhouses, glasshouse, shade net, poly tunnels - Design and development of low cost greenhouse structures. Seed and planting material; meeting export standards, implications of plant variety protection – patent regimes.

PRACTICALS

1. Export promotion zones and export scenario of fresh fruits and their products(1)
2. Practical exercises on quality standards of fruits for export purpose(2)
3. Quality standards of planting material and seeds(2)
4. Hi-tech nursery in fruits(1)
5. Practicals on ISO specifications and HACCP for export of fruits(3)
6. Sanitary and phyto-sanitary measures during export of horticultural produce(2)
7. Post harvest management chain of horticultural produce for exports(2)
8. Visit to export oriented units/agencies like APEDA, NHB, etc.

FSC-531 GROWTH AND DEVELOPMENT OF FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Principles: Growth and development- definition, parameters of growth and development, growth dynamics and morphogenesis.

Block 2: Environment and Development

UNIT I: Climatic Factors, Hormones and Developmental Physiology: Environmental impact on growth and development- effect of light, temperature, photosynthesis and photoperiodism, vernalisation, heat units and thermoperiodism. Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brassinosteroids, other New PGRs. Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

Block 3: Stress Management

UNIT I: Strategies for Overcoming Stress: Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations and Commercial application of PGRs in fruit crops, molecular and genetic approaches in plant growth and development.

PRACTICALS

1. Understanding dormancy mechanisms in fruit crops and seed stratification (2)
2. Techniques of growth analysis(2)
3. Evaluation of photosynthetic efficiency under different environments(2)
4. Exercises on hormone assays(2)
5. Practicals on use of growth regulators(2)
6. Understanding ripening phenomenon in fruits(2)
7. Study on impact of physical manipulations on growth and development(1)
8. Study on chemical manipulations on growth and development(1)
9. Understanding stress impact on growth and development(1)

RESOURCES

Bhatnagar, P. 2017. *Physiology of Growth and Development of Horticultural Crops*. Agrobios (India).

Buchanan, B., Gruissem, W. and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley & Sons, NY, USA.

Dhillon, W.S. and Bhatt, Z. A., 2011. *Fruit Tree Physiology*. Narendra Publishing House, New Delhi.

Durner, E. 2013. *Principles of Horticultural Physiology*. CAB International.

Epstein, E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. John Wiley & Sons, NY, USA.

Faust, M. 1989. *Physiology of Temperate Zone Fruit Trees*. John Wiley & Sons, NY, USA.

Fosket, D.E. 1994. *Plant Growth and Development : a Molecular Approach*. Academic Press, USA.

Leopold, A.C. and Kriedemann, P.E., 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill, New Delhi.

Roberts, J., Downs, S. and Parker, P., 2002. *Plant Growth Development*. In: Salisbury, F.B. and Ross, C.W. (Eds.) *Plant Physiology*. 4th Ed. Wadsworth Publications, USA.

Schaefer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of Fruit Crops*. Vol. 1 & 2. CRC Press. USA.

Seymour, G. B., Taylor, J. E. and Tucker, G.A., 1993. *Biochemistry of Fruit Ripening*. Chapman & Hall, London

FSC-532 NUTRITION OF FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Principles: Importance and history of nutrition in fruit crops, essential plant nutrients, factors affecting plant nutrition; nutrient uptake and their removal from soil.

Block 2: Requirements and Applications

UNIT I: Diagnostics, Estimation and Application: Nutrient requirements, root distribution in fruit crops, soil and foliar application of nutrients in major fruit crops, fertilizer use efficiency. Methods and techniques for evaluating the requirement of macro- and micro- elements, Diagnostic and interpretation techniques including DRIS. Role of different macro- and micro-nutrients, their deficiency and toxicity disorders, corrective measures to overcome deficiency and toxicity disorders.

Block 3: Newer Approaches

UNIT I: Integrated Nutrient Management (INM): Fertigation in fruit crops, bio-fertilizers and their use in INM systems.

PRACTICALS

1. Visual identification of nutrient deficiency symptoms in fruit crops (2)
2. Identification and application of organic, inorganic and bio-fertilizers(1)
3. Soil/tissue collection and preparation for macro- and micro-nutrient analysis(1)
4. Analysis of soil physical and chemical properties- pH, EC, Organic carbon(1)
5. Determination of N,P,K and other macro- and micronutrients (6)
6. Fertigation in glasshouse and field grown horticultural crops(2)
7. Preparation of micro-nutrient solutions, their spray and soil applications(2)

RESOURCES

Atkinson, D., Jackson, J. E. and Sharples, R. O. 1980. *Mineral Nutrition of Fruit Trees*.

Butterworth – Heinemann.

Bould, C., Hewitt, E.J. and Needham, P. 1983. *Diagnosis of Mineral Disorders in Plants Vol.1 Principles*. Her Majesty's Stationery Office, London.

Cooke, G.W. 1972. *Fertilizers for maximizing yield*. Grenada Publishing Ltd, London. Epstein, E. 1972. *Mineral Nutrition of Plants: Principles & Perspectives*. Wiley Eastern Ltd. Kanwar, J.S. 1976. *Soil Fertility- Theory and Practice*. ICAR, New Delhi.

Marchner, Horst. 1995. *Mineral Nutrition of Higher Plants*, 2nd Ed. Marschner, Academic Press Inc. San Diego, CA.

Mengel, K. and Kirkby, E.A. 1987. *Principles of Plant Nutrition*. 4th Ed. International Potash Institute, Worblaufen-Bern, Switzerland.

Prakash, M. 2013. *Nutritional Disorders in Fruit Crops: Diagnosis and Management*. NIPA, New Delhi.

Tandon, H.L.S. 1992. *Management of Nutrient Interactions in Agriculture*. Fertilizer Development and Consultation Organization, New Delhi.

Westerman, R.L. 1990. *Soil Testing and Plant Analysis*, 3rd Ed. Soil Science Society of America, Inc., Madison, WI.

Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 1972. *Manures and Fertilizers*. 3rd Ed. Agri Horticultural Publishing House, Nagpur.

FSC-533 BIOTECHNOLOGY OF FRUIT CROPS (2+1)

THEORY

Block 1: General Background

UNIT I: Introduction, History and Basic Principles: Introduction and significance, history and basic principles, influence of explant material, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture

Block 2: Tissue Culture

UNIT I: *In vitro* Culture and Hardening: Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis ; Organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture. Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues. Hardening and *ex vitro* establishment of tissue cultured plants

Block 3: Genetic Manipulation

UNIT I: *In vitro* Breeding, Transgenics and Gene Technologies: Somatic cell hybridisation, construction and identification of somatic hybrids and cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, *In vitro* selection for biotic and abiotic stress. Genetic engineering- principles and methods,

transgenics in fruit crops, use of molecular markers and genomics. Gene silencing, gene tagging, gene editing, achievements of biotechnology in fruit crops.

PRACTICALS

1. An exposure to low cost, commercial and homestead tissue culture laboratories(2)
2. Media preparation, Inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus(3)
3. Sub-culturing techniques on anther, ovule, embryo culture, somaclonal variation(4)
4. *In vitro* mutant selection against abiotic stress(2)
5. Protoplast culture and fusion technique(2)

6. Development of protocols for mass multiplication(2)
7. Project development for establishment of commercial tissue culture laboratory(1)

RESOURCES

- Bajaj, Y.P.S., Eds., 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, *Fruits*. Springer, USA.
- Brown, T.A., 2001. *Gene Cloning and DNA Analysis and Introduction*. Blackwell Publishing, USA.
- Chahal, G.S. and Gosal, S.S., 2010. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Narosa, New Delhi.
- Chopra, V.L. and Nasim, A., 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications*. Oxford & IBH, New Delhi.
- Keshavachandran, R. and Peter, K.V. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman, Universal Press, US.
- Keshavachandran, R., Nazeem, P.A., Girija, D., John, P.S. and Peter, K.V. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. NIPA, New Delhi.
- Kale, C. 2013. *Genome Mapping and Molecular Breeding in Plant*. Vol 4 Fruit and Nuts. Springer
- Litz, R. E. 2005. *Biotechnology of Fruit and Nut Crops*. CABI, UK.
- Miglani, G.S. 2016. *Genetic Engineering – Principles, Procedures and Consequences*. Narosa Publishing House, New Delhi.
- Parthasarathy, V.A., Bose, T.K., Dekka, P.C., Das, P., Mitra, S.K. and Mohanadas, S., 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash, Kolkata.
- Peter, K.V. 2013. *Biotechnology in Horticulture: Methods & Applications*. NIPA, New Delhi.
- Vasil, T.K., Vasi, M., While, D.N.R. and Bery, H.R. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Platinum Press, UK.

FSC-534 CLIMATE CHANGE AND FRUIT CROPS (1+0)

THEORY

Block 1: General Aspects

UNIT I: Introduction, Global Warming and Climatic Variability: Introduction to climate change. Factors directly affecting climate change. Global warming, effect of climate change on spatio-temporal patterns of temperature and rainfall, concentrations of greenhouse gases in atmosphere. pollution levels such as tropospheric ozone, change in climatic variability and extreme events.

Block 2: Climate Change and Management

UNIT I: Impact Assessment and Mitigation: Sensors for recording climatic parameters, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, longer growing seasons and shifts in plant hardiness for fruit crops.

Climate mitigation measures through crop management- use of tolerant rootstocks and varieties, mulching - use of plastic- windbreak- spectral changes- protection from frost and heat waves. Climate management in greenhouse- heating - vents - CO₂ injection - screens - artificial light. Impact of climate changes on invasive insect, disease, weed, fruit yield, quality and sustainability. Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems.

Block 3: Case Studies

UNIT I: Response to Climate Change: Case studies – responses of fruit trees to climatic variability *vis-à-vis* tolerance and adaptation ; role of fruit tree in carbon sequestration.

RESOURCES

- Dhillon, W.S. and Aulakh, P.S. 2011. *Impact of Climate Change in Fruit Production*. Narendra Publishing House, New Delhi.
- Peter, K.V. 2008. *Basics in Horticulture*. New India Publishing Agency, New Delhi.
- Ramirez , F. and Kallarackal, J. 2015. *Responses of Fruit Trees to Global Climate Change*. Springer- Verlag.
- Rao, G.S.L.H.V. 2008. *Agricultural Meteorology*. Prentice Hall, New Delhi.
- Rao, G.S.L.H.V., Rao, G.G.S.N., Rao, V.U.M. and Ramakrishnan, Y.S. 2008. *Climate Change and Agriculture over India*. ICAR, New Delhi.
- Schafeer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of Fruit Crops*. Vol. 1 & 2. CRC Press. USA.

(ii) M.Sc. (Hort.) Vegetable Science

Major courses

Course Code	Course Title	Credit hrs
Semester I		
VSC-511*	Production of Cool Season Vegetable Crops	2+1
VSC-512*	Growth and Development of Vegetable Crops	2+1
VSC-513*	Principles of Vegetable Breeding	2+1
VSC-514	Breeding of Self Pollinated Vegetable Crops	2+1
VSC-515	Systematics of Vegetable Crops	1+1
Semester II		
VSC-521*	Production of Warm Season Vegetable Crops	2+1
VSC-522	Seed Production of Vegetable Crops	2+1
VSC-523	Production of Spice Crops	2+1
VSC-524	Breeding of Cross Pollinated Vegetable Crops	2+1
VSC-525	Production of Underutilized Vegetable Crops	2+1
Semester III		
VSC-531	Protected Cultivation of Vegetable Crops	2+1
VSC-532	Organic Vegetable Production	1+1
VSC-533	Processing of Vegetable	1+1
VSC-534	Postharvest Management of Vegetable Crops	2+1
VSC-591	Seminar	1+0
Semester IV		
VSC -500	Research	0+30

* Core and compulsory courses.

Note: A student has to opt total 20 credit hours.

Syllabus of Major courses of Vegetable Science

VSC-511 PRODUCTION OF COOL SEASON VEGETABLE CROPS (2+1)

THEORY

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery, sowing/planting time and methods, hydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Unit I: *Bulb and tuber crops*- Onion, garlic and potato

Unit II: *Cole crops*- Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale

Unit III: *Root crops*- Carrot, radish, turnip and beetroot

Unit IV: *Peas and beans*- Garden peas and broad bean

Unit V: *Leafy vegetables*- beet leaf, fenugreek, coriander and lettuce

PRACTICAL

- Scientific raising of nursery and seed treatment
- Sowing and transplanting
- Description of commercial varieties and hybrids
- Demonstration on methods of irrigation, fertilizers and micronutrients application
- Mulching practices, weed management
- Use of plant growth substances in cool season vegetable crops
- Study of nutritional and physiological disorders
- Studies on hydroponics, aeroponics and other soilless culture
- Identification of important pest and diseases and their control
- Preparation of cropping scheme for commercial farms
- Visit to commercial farm, greenhouse/polyhouses
- Visit to vegetable market
- Analysis of benefit to cost ratio

RESOURCES

- Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003. Vegetable crops. Vols. I-III. Naya udyog.
- Bose, T.K., Som, M.G. and Kabir, J. (Eds.). 1993. Vegetable crops. Naya prokash.
- Chadha, K.L. and Kalloo, G. (Eds.), 1993-94. Advances in horticulture Vols. V-X. Malhotra publ. house.
- Chadha, K.L. (Ed.), 2002. Hand book of horticulture. ICAR.
- Chauhan, D.V.S. (Ed.), 1986. Vegetable production in India. Ram prasad and sons.
- Fageria, M.S., Choudhary, B.R. and Dhaka, R.S., 2000, Vegetable crops: production technology. Vol. II. Kalyani publishers.
- Gopalakrishnan, T.R., 2007, Vegetable crops. New India publ. agency.
- Hazra, P. and Banerjee M.K. and Chattopadhyay, A., 2012, Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana , 199
- Hazra, P., 2016, Vegetable science. 2ndedn, Kalyani publishers, Ludhiana.
- Hazra, P., 2019, Vegetable production and technology. New India publishing agency, New Delhi.
- Hazra, P., Chattopadhyay, A., Karmakar K. and Dutta, S., 2011, Modern technology for vegetable production, New India publishing agency, New Delhi, 413p
- Rana, M.K., 2008, Olericulture in India. Kalyani publ.
- Rana, M.K., 2008, Scientific cultivation of vegetables. Kalyani publ.
- Rana, M.K., 2014, Technology for vegetable production. Kalyani publishers, New Delhi.
- Rubatzky, V.E. and Yamaguchi, M. (Eds.), 1997, World vegetables: principles, production and nutritive values. Chapman and Hall.
- Saini, G.S., 2001, A text book of oleri and flori culture. Aman publishing house.
- Salunkhe, D.K. and Kadam, S.S. (Ed.), 1998, Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.
- Shanmugavelu, K.G., 1989, Production technology of vegetable crops. Oxford and IBH
- Singh, D.K., 2007, Modern vegetable varieties and production technology. International book distributing Co.
- Singh, S.P. (Ed.), 1989, Production technology of vegetable crops. Agril. comm. res. centre.
- Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR. Thompson, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.

THEORY

Unit I: *Introduction and phytohormones*- Definition of growth and development; Cellular structures and their functions; Physiology of phyto-hormones functioning/biosynthesis and mode of action; Growth analysis and its importance in vegetable production

Unit II: *Physiology of dormancy and germination*- Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellins, cytokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production

Unit III: *Abiotic factors*- Impact of light, temperature, photoperiod, carbon dioxide, oxygen and other gases on growth, development of underground parts, flowering and sex expression in vegetable crops; Apical dominance

Unit IV: *Fruit physiology*- Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening

Unit V: *Morphogenesis and tissue culture*- Morphogenesis and tissue culture techniques in vegetable crops; grafting techniques in different vegetable crops

PRACTICAL

- Preparation of plant growth regulator's solutions and their application
- Experiments in breaking and induction of dormancy by chemicals
- Induction of parthenocarpy and fruit ripening
- Application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables
- Growth analysis techniques in vegetable crops
- Grafting techniques in tomato, brinjal, cucumber and sweet pepper

RESOURCES

Bleasdale, J.K.A., 1984, Plant physiology in relation to horticulture (2nd Edition) MacMillan. Gupta, U.S., Eds., 1978, Crop physiology. Oxford and IBH, New Delhi.

Kaloo, G. 2017. Vegetable grafting: Principles and practices. CAB International Krishnamoorti, H.N., 1981, Application growth substances and their uses in agriculture. Tata McGraw Hill, New Delhi.

Leopold, A.C. and Kriedemann, P. E., 1981, Plant growth and development, Tata McGraw- Hill, New Delhi.

Peter, K.V. and Hazra, P. (Eds), 2012, Hand book of vegetables. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p

Peter, K.V., (Eds), 2008, Basics of horticulture. New India publication agency, New Delhi. Rana, M.K., 2011. *Physio-biochemistry and Biotechnology of Vegetables*. New India Publishing Agency, Pritam Pura, New Delhi.

Saini *et al.* (Eds.), 2001, Laboratory manual of analytical techniques in horticulture. Agrobios, Jodhpur.

Wien, H.C. (Eds.), 1997, The physiology of vegetable crops. CAB International.

VSC-513 PRINCIPLES OF VEGETABLE BREEDING (2+1)

THEORY

Unit I: *Importance and history*- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding

Unit II: *Selection procedures*- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE)

Unit III: *Heterosis breeding*- Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms

Unit IV: *Mutation and Polyploidy breeding*; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment

Unit V: *Ideotype breeding*- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of *In vitro* and molecular techniques in vegetable improvement

PRACTICAL

1. Floral biology and pollination behaviour of different vegetables
2. Techniques of selfing and crossing of different vegetables *viz.*, Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, *etc.*
3. Breeding system and handling of filial generations of different vegetables
4. Exposure to biotechnological lab practices.
5. Visit to breeding farms

RESOURCES

Allard, R.W., 1960, Principle of plant breeding. John Willey and Sons, USA.

Kalloo, G., 1988, Vegetable breeding (Vol. I, II, III). CRC Press, FI, USA.

Kole, C.R. 2007, Genome mapping and molecular breeding in plants-vegetables. Springer, USA.

Peter, K.V. and Pradeep Kumar, T., 1998, Genetics and breeding of vegetables. ICAR, New Delhi, p. 488

Prohens, J. and Nuez, F., 2007, Handbook of plant breeding-vegetables (Vol I and II). Springer, USA.

Singh, B.D., 2007, Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.

Singh, Ram J., 2007, Genetic resources, chromosome engineering, and crop improvement- vegetable crops(Vol. 3). CRC Press, FI, USA.

VSC-514 BREEDING OF SELF POLLINATED VEGETABLE CROPS (2+1)

THEORY

Origin, botany, taxonomy, wild relatives, cytogenetics and genetics, types of pollination and fertilization mechanism, sterility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation and polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses,

breeding for protected environment and quality improvement, molecular markers and marker's assisted breeding; QTLs, PPV and FR Act.

Unit I: *Tuber crops*: Potato

Unit II: *Fruit vegetables*- Tomato, eggplant, hot pepper, sweet pepper and okra

Unit III: *Leguminous vegetables*- Garden peas and cowpea

Unit IV: *Leguminous vegetables*: French bean, Indian bean, cluster bean and broad bean

Unit V: *Leafy vegetables*- Lettuce and fenugreek

PRACTICAL

- Floral mechanisms favouring self and often cross pollination
- Progeny testing and development of inbred lines
- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations
- Palynological studies, selfing and crossing techniques
- Hybrid seed production of vegetable crops in bulk
- Screening techniques for biotic and abiotic stress resistance in above mentioned crops
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques
- Visit to breeding farms

RESOURCES

Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons. Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.

Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: Breeding and seed production. Vol. I. Kalyani.

Gardner, E.J., 1975, Principles of genetics. John Wiley and Sons.

Hayes, H.K., Immer, F.R. and Smith, D.C., 1955, Methods of plant breeding. McGraw-Hill.

Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.), 1993, Plant Breeding-principles and prospects. Chapman and Hall.

Hazra, P. and Som, M.G., 2015, Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p

Hazra, P. and Som, M.G., 2016, Vegetable seed production and hybrid technology(Second revised edition), Kalyani Publishers, Ludhiana, 459 p

Kaloo, G., 1988, Vegetable breeding. Vols. I-III. CRC Press.

Kaloo, G., 1998, Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro Botanical Publ.

Paroda, R.S. and Kaloo, G. (Eds.), 1995, Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.

Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables. Revised, ICAR.

- Peter, K.V. and Hazra, P. (Eds), 2012, Hand book of vegetables. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
- Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency. Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ.
- Simmonds, N.W., 1978, Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publ.
- Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International Book Distributing Co.
- Swarup, V., 1976, Breeding procedure for cross-pollinated vegetable crops. ICAR.

VSC-515 SYSTEMATICS OF VEGETABLE CROPS (1+1)

THEORY

UNIT I: *Significance of systematic*- Significance of systematics and crop diversity in vegetable crops; Principles of classification; different methods of classification; Salient features of international code of nomenclature of vegetable crops

UNIT II: *Origin and evolution*- Origin, history, evolution and distribution of vegetable crops UNIT III: *Botanical and morphological description*- Botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Morphological keys to identify important families, floral biology, floral formula and diagram; Morphological description of all parts of vegetables

UNIT IV: *Cytology*- Cytological level of various vegetable crops with descriptive keys

UNIT V: *Molecular markers*- Importance of molecular markers in evolution of vegetable crops; Molecular markers as an aid in characterization and taxonomy of vegetable crops

PRACTICAL

1. Identification, description, classification and maintenance of vegetable species and varieties
2. Survey, collection of allied species and genera locally available
3. Preparation of keys to the species and varieties
4. Methods of preparation of herbarium and specimens

RESOURCES

- Chopra, G.L., 1968, Angiosperms- systematics and life cycle. S. Nagin Dutta, A.C., 1986, A class book of botany. Oxford Univ. Press.
- Pandey, B.P., 1999, Taxonomy of angiosperm. S. Chand and Co
- Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables. (Revised), ICAR.
- Peter, K.V. and Hazra, P. (Eds), 2012, Hand book of vegetables. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.

- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume II. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
- Simmonds, N.W. and Smartt, J., 1995, Evolution of crop plants. Wiley-Blackwell.
- Soule, J., 1985, Glossary for Horticultural Crops. John Wiley and Sons.
- Srivastava, U., Mahajan, R.K., Gangopadhyay, K.K., Singh, M. and Dhillon, B.S., 2001, Minimal descriptors of agri-horticultural crops. Part-II: Vegetable Crops. NBPGR, New Delhi.
- Vasistha, 1998, Taxonomy of angiosperm. Kalyani Publ.
- Vincent, E.R. and Yamaguchi, M., 1997, World vegetables. 2nd Ed. Chapman and Hall.

VSC-521 PRODUCTION OF WARM SEASON VEGETABLE CROPS (2+1)

THEORY

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of crops.

Unit I: *Fruit vegetables*- Tomato, brinjal, hot pepper, sweet pepper and okra

Unit II: *Beans*- French bean, Indian bean (Sem), cluster bean and cowpea

Unit III: *Cucurbits*- Cucumber, melons, gourds, pumpkin and squashes

Unit IV: *Tuber crops*- Sweet potato, elephant foot yam, tapioca, taro and yam

Unit V: *Leafy vegetables*- Amaranth and drumstick

PRACTICAL

- Scientific raising of nursery and seed treatment
- Sowing, transplanting, vegetable grafting
- Description of commercial varieties and hybrids
- Demonstration on methods of irrigation, fertilizers and micronutrients application
- Mulching practices, weed management
- Use of plant growth substances in warm season vegetable crops
- Study of nutritional and physiological disorders
- Studies on hydroponics, aeroponics and other soilless culture
- Identification of important pest and diseases and their control
- Preparation of cropping scheme for commercial farms
- Visit to commercial farm, greenhouse/polyhouses
- Visit to vegetable market
- Analysis of benefit to cost ratio

RESOURCES

- Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003, Vegetable crops. Vols. I-III. Naya udyog.
- Bose, T.K., Som, M.G. and Kabir, J. (Eds.), 1993, Vegetable crops. Naya prokash.
- Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances in horticulture Vols. V-X. Malhotra publ. house.
- Chadha, K.L. (Ed.), 2002, Hand book of horticulture. ICAR.
- Chauhan, D.V.S. (Ed.), 1986, Vegetable production in India. Ram prasad and sons.
- Fageria, M.S., Choudhary, B.R. and Dhaka, R.S., 2000, Vegetable crops: production technology. Vol. II. Kalyani.
- Gopalakrishnan, T.R., 2007, Vegetable crops. New India publ. agency.
- Hazra, P. and Banerjee, M. K. and Chattopadhyay, A. (2012), Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana , 199 p
- Hazra, P., 2016, Vegetable science. 2ndedn, Kalyani publishers, Ludhiana.
- Hazra, P., 2019, Vegetable production and technology. New India publishing agency, New Delhi.
- Hazra, P., Chattopadhyay, A., Karmakar, K. and Dutta, S., (2011), Modern technology for vegetable production, New India publishing agency, New Delhi, 413p
- Rana, M.K., 2008, Olericulture in India. Kalyani publ.
- Rana, M.K., 2008, Scientific cultivation of vegetables. Kalyani publ.
- Rubatzky, V.E. and Yamaguchi, M. (Eds.), 1997, World vegetables: principles, production and nutritive values. Chapman and Hall.
- Saini, G.S., 2001, A text book of oleri and flori culture. Aman publishing house.
- Salunkhe, D.K. and Kadam, S.S. (Ed.), 1998, Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.
- Shanmugavelu, K.G., 1989, Production technology of vegetable crops. Oxford and IBH.
- Singh, D.K., 2007, Modern vegetable varieties and production technology. International book distributing Co.
- Singh, S.P. (Ed.), 1989, Production technology of vegetable crops. Agril. comm. res. centre. Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR. Thompson, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.

VSC-522 SEED PRODUCTION OF VEGETABLE CROPS (2+1)

THEORY

UNIT I: *Introduction, history, propagation and reproduction*- Introduction, definition of seed and its quality, seed morphology, development and maturation; Apomixis and fertilization; Modes of propagation and reproductive behaviour; Pollination mechanisms and sex forms in vegetables; History of vegetable seed production; Status and share of vegetable seeds in seed industry

UNIT II: *Agro-climate and methods of seed production*- Agro-climate and its influence on quality seed production; Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production; Methods of seed production, hybrid seeds and techniques of large scale hybrid seed production; Seed village concept

UNIT III: *Seed multiplication and its quality maintenance*- Seed multiplication ratios and replacement rates in vegetables; Generation system of seed multiplication; Maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds; Seed quality and mechanisms of genetic purity testing

UNIT IV: *Seed harvesting, extraction and its processing*- Maturity standards; Seed harvesting, curing and extraction; Seed processing viz., cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing; Principles of seed storage; Orthodox and recalcitrant seeds; Seed dormancy

UNIT V: *Improved agro-techniques and field and seed standards*- Improved agro- techniques; Field and seed standards in important solanaceous, leguminous and cucurbitaceous vegetables, cole crops, leafy vegetables, bulbous and root crops and okra; clonal propagation and multiplication in vegetative propagated crops; Seed plot technique and true potato seed production in potato

PRACTICAL

1. Study of floral biology and pollination mechanisms in vegetables
2. Determination of modes of pollination
3. Field and seed standards
4. Use of pollination control mechanisms in hybrid seed production of important vegetables
5. Maturity standards and seed extraction methods
6. Seed sampling and testing
7. Visit to commercial seed production areas
8. Visit to seed processing plant
9. Visit to seed testing laboratories

RESOURCES

- Agarwal, P. K. and Anuradha, V., 2018, Fundamentals of seed science and technology. Brilliant publications, New Delhi.
- Agrawal, P.K. and Dadlani M. (Eds.), 1992, Techniques in seed science and technology. South Asian Publ.
- Agrawal, R.L. (Ed.), 1997, Seed technology. Oxford and IBH.
- Basra, A.S., 2000, Hybrid seed production in vegetables. CRC press, Florida, USA.
- Bench, A.L.R. and Sanchez, R.A., 2004, Handbook of seed physiology. Food products press, NY/ London.
- Bendell, P.E. (Eds.), 1998, Seed science and technology: Indian forestry species. Allied Publ.
- Chakraborty, S.K., Prakash, S., Sharma, S.P. and Dadlani, M., 2002, Testing of distinctiveness, uniformity and stability for plant variety protection. IARI, New Delhi
- Copland, L.O. and McDonald, M.B., 2004, Seed science and technology, Kluwer Academic Press.
- Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: breeding and seed production. Vol. I. Kalyani Publ.
- George, R.A. T., 1999, Vegetable seed production (2nd Edition). CAB International.
- Hazra, P. and Som, H.G. 2015, Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.
- Kaloo, G., Jain, S.K., Vari, A.K. and Srivastava, U., 2006, Seed: A global perspective. Associated publishing company, New Delhi.
- Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro botanical publ.
- More, T.A., Kale, P.B. and Khule, B.W., 1996, Vegetable seed production technology. Maharashtra state seed corp.
- Rajan, S. and Markose, B. L., 2007, Propagation of horticultural crops. New India publ. agency.
- Singh, N.P., Singh, D.K., Singh, Y.K. and Kumar, V., 2006, Vegetable seed production technology. International book distributing Co.
- Singh, S.P., 2001, Seed production of commercial vegetables. Agrotech publ. academy.
- Singhal, N.C., 2003, Hybrid seed production. Kalyani publishers, New Delhi.

VSC-523 PRODUCTION OF SPICE CROPS (2+1)

THEORY

Introduction and importance of spice crops- historical accent, present status (national and international), future prospects, botany and taxonomy, climatic and soil requirement, commercial cultivars/hybrids, site selection, layout, sowing/planting time and methods, seed rate and seed treatment, nutritional and irrigation requirement, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post- harvest management, plant protection measures, quality control and pharmaceutical significance of crops mentioned below:

UNIT I: *Fruit spices*- Black pepper, small cardamom, large cardamom and allspice UNIT II: *Bud and kernel*- Clove and nutmeg

UNIT III: *Underground spices*- Turmeric, ginger and garlic

UNIT IV: *Seed spices*- Coriander, fenugreek, cumin, fennel, ajowain, dill and celery UNIT V: *Tree spices*- Cinnamon, tamarind, garcinia and vanilla

PRACTICAL

- Identification of seeds and plants
- Botanical description of plant
- Preparation of spice herbarium
- Propagation
- Nursery raising
- Field layout and method of planting
- Cultural practices
- Harvesting, drying, storage, packaging and processing
- Value addition
- Short term experiments on spice crops

RESOURCES

- Agarwal, S., Sastry, E.V.D. and Sharma, R.K., 2001, Seed spices: production, quality, export. Pointer Publication.
- Arya, P.S., 2003, Spice crops of India. Kalyani.
- Bhattacharjee, S.K., 2000, Hand book of aromatic plants. Pointer publications.
- Bose, T.K., Mitra, S.K., Farooqi, S.K. and Sadhu, M.K. (Eds.), 1999, Tropical horticulture. Vol.I. Naya Prokash.
- Chadha, K.L. and Rethinam, P. (Eds.), 1993, Advances in horticulture. Vols. IX-X. Plantation crops and spices. Malhotra Publ. House.
- Gupta, S. (Ed.), Hand book of spices and packaging with formulae. engineers India research institute, New Delhi.
- Kumar, N.A., Khader, P., Rangaswami and Irulappan, I., 2000, Introduction to spices, plantation crops, medicinal and aromatic plants. Oxford and IBH.
- Nybe, E.V., Miniraj, N. and Peter, K.V., 2007, Spices. New India Publ. Agency. Parthasarthy, V.A., Kandiannan, V. and Srinivasan, V., 2008, Organic spices. New India Publ. Agency.
- Peter, K.V., 2001, Hand book of herbs and spices. Vols. I-III. Woodhead Publ. Co. UK and CRC USA
- Pruthi, J.S. (Ed.), 1998, Spices and condiments. National Book Trust
- Pruthi, J.S., 2001, Minor spices and condiments- crop management and post harvest technology. ICAR.

Purseglove, J.W., Brown, E.G., Green, C.L. and Robbins, S.R.J. (Eds.), 1981, Spices. Vols. I, Longman.

Shanmugavelu, K.G., Kumar, N. and Peter, K.V., 2002, Production technology of spices and plantation crops. Agrobios.

Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR.

Tiwari, R.S. and Agarwal, A., 2004, Production technology of spices. International Book Distr. Co.

Varmudy, V., 2001, Marketing of spices. Daya Publ. House.

VSC-524 BREEDING OF CROSS-POLLINATED VEGETABLE CROPS (2+1)

THEORY

Origin, botany, taxonomy, cytogenetics, genetics, types of pollination and fertilization, mechanism, sterility and incompatibility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation, polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, quality improvement, molecular markers and marker assisted breeding, and QTLs, PPV and FR act

Unit I: *Cucurbitaceous crops*- Gourds, melons, cucumber, pumpkin and squashes

Unit II: *Cole crops*- Cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts

Unit III: *Root and bulb crops*- Carrot, radish, turnip, beet root and onion

Unit IV: *Tuber crops*- Sweet potato, tapioca, taro and yam

Unit V: *Leafy vegetables*- Beet leaf, spinach, amaranth and coriander

PRACTICAL

- Floral mechanisms favouring cross pollination
- Development of inbred lines
- Selection of desirable plants from breeding population
- Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations
- Induction of flowering, palynological studies, selfing and crossing techniques
- Hybrid seed production of vegetable crops in bulk; Screening techniques for biotic and abiotic stress resistance in above mentioned crops
- Demonstration of sib-mating and mixed population
- Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques
- Visit to breeding blocks

RESOURCES

Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons.

Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa publ. house.

Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: breeding and seed production. Vol. I. Kalyani.

Gardner, E.J., 1975, Principles of genetics. John Wiley and Sons.

Hayes, H.K., Immer, F.R. and Smith, D.C., 1955, Methods of plant breeding. McGraw-Hill.

Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.), 1993, Plant breeding-principles and prospects. Chapman and Hall.

- Hazra, P. and Som M.G., 2015, Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p
- Hazra, P. and Som, M.G., 2016, Vegetable seed production and hybrid technology(Second revised edition), Kalyani Publishers, Ludhiana, 459 p
- Kaloo, G., 1988, Vegetable breeding. Vols. I-III. CRC Press.
- Kaloo, G., 1998, Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
- Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro botanical publ.
- Paroda, R.S. and Kaloo, G. (Eds.), 1995, Vegetable research with special reference to hybrid technology in Asia-Pacific region. FAO.
- Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables.revised, ICAR. Peter, K.V. and Hazra, P. (Eds), 2012,Hand book of vegetables.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
- Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables Volume II and III.Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
- Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency. Prohens, J. and Nuez, F. 2007. Handbook of Plant Breeding- Vegetables (Vol I and II), Springer, USA.
- Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ. Simmonds, N.W., 1978, Principles of crop improvement. Longman.
- Singh, B.D., 1983, Plant breeding. Kalyani Publ.
- Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International book distributing Co.
- Swarup, V., 1976, Breeding procedure for cross-pollinated vegetable crops. ICAR.

VSC-525 PRODUCTION OF UNDERUTILIZED VEGETABLE CROPS (2+1)

THEORY

Importance and scope, botany and taxonomy, climate and soil requirement, commercial varieties/hybrids, improved cultural practices, physiological disorders, harvesting and yield, plant protection measures and post-harvest management of:

UNIT I: *Stem and bulb crops*- Asparagus, leek and chinese chive

UNIT II: *Cole and salad crops*- Red cabbage, Chinese cabbage, kale, sweet corn and baby corn

UNIT IV: *Gourds and melons*- Sweet gourd, spine gourd, teasle gourd, round gourd, and little/Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snap melon and gherkin UNIT III: *Leafy vegetables*- Celery, parsley, indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance

UNIT V: *Yam and beans*- Elephant foot yam, yam, yam bean, lima bean and winged bean

PRACTICAL

- Identification and botanical description of plants and varieties
- Seed/planting material
- Production, lay out and method of planting
- Important cultural operations
- Identification of important pests and diseases and their control
- Maturity standards and harvesting

- Visit to local farms

RESOURCES

- Bhat, K.L., 2001, Minor vegetables-untapped potential. Kalyani publishers, New Delhi.
- Indira, P. and Peter, K.V., 1984, Unexploited tropical vegetables. Kerala agricultural university, Kerala.
- Pandey, A.K., 2011, Aquatic vegetables. Agrotech publisher academy, New Delhi.
- Peter, K.V. (Eds.), 2007-08, Underutilized and underexploited horticultural crops. Vol.1-4, New India publishing agency, Lucknow.
- Peter, K.V. and Hazra, P. (Eds), 2012, Hand book of vegetables. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume II and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
- Rana, M.K., 2018. Vegetable crop science. CRC Press Taylor and Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 ISBN: 978-1- 1380-3521-8
- Rubatzky, V.E. and Yamaguchi, M., 1997, World vegetables: vegetable crops. NBPGR, New Delhi.

VSC-531 PROTECTED CULTIVATION OF VEGETABLE CROPS (2+1)

THEORY

UNIT I: *Scope and importance*- Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/greenhouse structures

UNIT II: *Types of protected structure*- Classification and types of protected structures- greenhouse/polyhouses, plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation, insect proof net houses, shed net houses, rain shelters, NVP, climate control greenhouses, hydroponics and aeroponics; Soil and soilless media for bed preparation; Design and installation of drip irrigation and fertigation system

UNIT III: *Abiotic factors*- Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.

UNIT IV: *Nursery raising*- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation

UNIT V: *Cultivation of crops*- Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures

UNIT VI: *Solutions to problems*- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production

PRACTICAL

1. Study of various types of protected structure
2. Study of different methods to control temperature, carbon dioxide and light
3. Study of different types of growing media, training and pruning systems in greenhouse crops
4. Study of fertigation and nutrient management under protected structures

5. Study of insect pests and diseases in greenhouse and its control
6. Use of protected structures in hybrid seed production of vegetables
7. Economics of protected cultivation (Any one crop)
8. Visit to established green/polyhouses/shade net houses in the region

RESOURCES

- Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances in horticulture. Malhotra Pub. House. Chandra, S. and Som, V., 2000, Cultivating vegetables in green house. Indian horticulture 45:17-18.
- Kalloo, G. and Singh, K. (Eds.), 2000, Emerging scenario in vegetable research and development. Research periodicals and Book publ. house.
- Parvatha, R. P., 2016, Sustainable crop protection under protected cultivation. E-Book Springer.
- Prasad, S. and Kumar, U., 2005, Greenhouse management for horticultural crops. 2nd Ed. Agrobios.
- Resh, H.M., 2012, Hydroponic food production. 7th Edn. CRC Press.
- Singh, B., 2005, Protected cultivation of vegetable crops. Kalyani publishers, New Delhi Singh, D.K. and Peter, K.V., 2014, Protected cultivation of horticultural crops (1st Edition) New India publishing agency, New Delhi.
- Singh, S., Singh, B. and Sabir, N., 2014, Advances in protected cultivation. New India publishing agency, New Delhi.
- Tiwari, G.N., 2003, Green house technology for controlled environment. Narosa publ. house.

VSC-532 ORGANIC VEGETABLE PRODUCTION (1+1)

THEORY

UNIT I: *Importance and principles*- Importance, principles, perspective, concepts and components of organic farming in vegetable crops

Unit II: *Organic production of vegetables*- Organic production of vegetable crops viz., Solanaceous, Cucurbitaceous, Cole, root and tuber crops

UNIT III: *Managing soil fertility*- Managing soil fertility, mulching, raising green manure crops, weed management in organic farming system; Crop rotation in organic production; Processing and quality control of organic vegetable produce

UNIT IV: *Composting methods*- Indigenous methods of composting, Panchyagavvya, Biodynamics preparations and their application; ITKs in organic vegetable farming; Role of botanicals and bio-control agents in the management of pests and diseases in vegetable crops

UNIT V: *Certification and export*- Techniques of natural vegetable farming, GAP and GMP- certification of organic products; Export- opportunity and challenges

PRACTICAL

1. Methods of preparation and use of compost, vermicompost, biofertilizers and biopesticides
2. Soil solarisation; Use of green manures
3. Waste management; Organic soil amendments in organic production of vegetable crops
4. Weed, pest and disease management in organic vegetable production
5. Visit to organic fields and marketing centres

RESOURCES

- Dahama, A.K., 2005, Organic farming for sustainable agriculture. 2nd Ed. Agrobios.
- Gehlot, G., 2005, Organic farming; standards, accreditation certification and inspection. Agrobios.

Palaniappan, S.P. and Annadorai, K., 2003. Organic farming, theory and practice. Scientific publ.

Pradeepkumar, T., Suma, B., Jyothibhaskar and Satheesan, K.N., 2008. Management of horticultural crops. New India Publ. Agency.

Shivashankar, K., 1997, Food security in harmony with nature. *3rd IFOAMASIA*, Scientific Conf..1- 4 December, UAS, Bangalore.

VSC-533 PROCESSING OF VEGETABLE CROPS (1+1)

THEORY

UNIT I: *Present status*- Present status and future prospects of vegetable preservation industry in India

UNIT II: *Spoilage and biochemical changes*- Spoilage of fresh and processed vegetable produce; biochemical changes and enzymes associated with spoilage of vegetable produce; Principal spoilage organisms, food poisoning and their control measures; Role of microorganisms in food preservation

UNIT III: *Processing equipments*- Raw material for processing; Primary and minimal processing; Processing equipments; Layout and establishment of processing industry; FPO licence; Importance of hygiene; Plant sanitation

UNIT IV: *Quality control*- Quality assurance and quality control, TQM, GMP; Food standards- FPO, PFA, etc.; Food laws and regulations; Food safety- hazard analysis and critical control points (HACCP); Labeling and labeling act and nutrition labeling

UNIT V: *Value addition*- Major value added vegetable products; Utilization of byproducts of vegetable processing industry; Management of processing industry waste; Investment analysis; Principles and methods of sensory evaluation of fresh and processed vegetables

PRACTICAL

- Study of machinery and equipments used in processing of vegetable produce
- Chemical analysis for nutritive value of fresh and processed vegetable
- Study of different types of spoilage in fresh as well as processed vegetable produce
- Classification and identification of spoilage organisms
- Study of biochemical changes and enzymes associated with spoilage
- Laboratory examination of vegetable products
- Sensory evaluation of fresh and processed vegetables
- Study of food standards- National, international, CODEX Alimentarius
- Visit to processing units to study the layout, hygiene, sanitation and waste management

RESOURCES

Arthey, D. and Dennis, C., 1996, Vegetable processing. Blackie/Springer-Verlag. Chadha, D.S., 2006, *The Prevention of food adulteration act*. Confed. of Indian Industry. Desrosier, N.W., 1977, Elements and technology. AVI Publ. Co.

FAO., 1997, Fruit and Vegetable processing. FAO.

FAO., *CODEX Alimentarius*: Joint FAO/WHO food standards programme. 2nd Ed. Vol. VB. tropical fresh fruits and vegetables. FAO.

FAO., Food quality and safety systems- training manual on food hygiene and haccp. FAO. Fellow's, P., 1988, Food processing technology. Ellis Horwood International.

Frazier, W.C. and Westhoff, D.C., 1995, Food microbiology. 4th Ed. Tata McGraw Hill. Giridharilal, G.S., Siddappa and Tandon, G.L., 1986, Preservation of fruits and vegetables. ICAR.

Gisela, J., 1985, Sensory evaluation of food- theory and practices. Ellis Horwood. Graham, H.D., 1980, Safety of foods. AVI Publ. Co.

- Hildegrade, H. and Lawless, H.T., 1997, Sensory evaluation of food. CBS. Joslyn, M. and Heid, Food processing operations. AVI Publ. Co.
- Mahindru, S.N., 2004, Food safety: concepts and reality. APH Publ. Corp.
- Ranganna, S., 1986, Handbook of analysis and quality control for fruit and vegetable products. 2nd Ed. Tata-McGraw Hill.
- Shapiro, R., 1995, Nutrition labeling handbook. Marcel Dekker.
- Srivastava, R.P. and Kumar, S., 2003, Fruit and vegetable preservation: principles and practices. 3rd Ed. International Book Distri. Co.
- Tressler and Joslyn, M.A., 1971, Fruit and vegetable juice processing technology. AVI Publ. Co. Verma, L.R. and Joshi, V.K., 2000, Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management. Indus Publ. Co.

VSC-534 POSTHARVEST MANAGEMENT OF VEGETABLE CROPS (2+1)

THEORY

UNIT I: Importance and scope- Importance and scope of post-harvest management of vegetables

UNIT II: Maturity indices and biochemistry- Maturity indices and standards for different vegetables; Methods of maturity determination; Biochemistry of maturity and ripening; Enzymatic and textural changes; Ethylene evolution and ethylene management; Respiration and transpiration along with their regulation methods

UNIT III: Harvesting and losses factors- Harvesting tools and practices for specific market requirement; Postharvest physical and biochemical changes; Preharvest practices and other factors affecting postharvest losses

UNIT IV: Packinghouse operations- Packing house operations; Commodity pretreatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation

UNIT V: Methods of storage- Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage; Zero-energy cool chamber, storage disorders like chilling injury in vegetables

PRACTICAL

- a) Studies on stages and maturing indices
- b) Ripening of commercially important vegetable crops
- c) Studies of harvesting, pre-cooling, pre-treatments, physiological disorders- chilling injury
- d) Improved packaging
- e) Use of chemicals for ripening and enhancing shelf life of vegetables
- f) Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release
- g) Storage of important vegetables
- h) Cold chain management
- i) Visit to commercial packinghouse, cold storage and control atmosphere storage

RESOURCES

- Chadha, K.L. and Pareek, O.P., 1996, Advances in horticulture. Vol. IV. Malhotra Publ. House.
- Chattopadhyay, S.K., 2007, Handling, transportation and storage of fruit and vegetables. Gene-Tech books, New Delhi.
- Haid, N.F. and Salunkhe, S.K., 1997, Postharvest physiology and handling of fruits and vegetables. Grenada Publ.

- Mitra, S.K., 1997, Postharvest physiology and storage of tropical and sub-tropical fruits. CABI.
- Paliyath G., Murr D.P., Handa, A.K. and Lurie, S., 2008, Postharvest biology and technology of Fruits, vegetables and flowers. Wiley-Blackwell, ISBN: 9780813804088.
- Ranganna, S., 1997, Handbook of analysis and quality control for fruit and vegetable Products. Tata McGraw-Hill.
- Stawley, J. K., 1998, Postharvest physiology of perishable plant products. CBS publishers. Sudheer, K.P. and Indira, V., 2007, Postharvest technology of horticultural crops. New India Publ. Agency.
- Thompson, A.K. (Ed.), 2014, Fruit and vegetables: harvesting, handling and storage (Vol. 1 and 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.
- Verma, L.R. and Joshi, V.K., 2000, Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
- Willis, R, McGlassen, W.B., Graham, D. and Joyce, D., 1998, Postharvest: An introduction to the physiology and handling of fruits, vegetables and ornamentals. CABI.
- Wills, R.B.H. and Golding, J., 2016, Postharvest: an introduction to the physiology and handling of fruit and vegetables, CABI Publishing, ISBN 9781786391483.
- Wills, R.B.H. and Golding, J., 2017, Advances in postharvest fruit and vegetable technology, CRC Press,.

M.Sc. (Hort.) Floriculture and Landscaping**Major Courses**

Course Code	Course Title	Credit hours
Major Courses (20 Credits)		
	Semester-I	
FLS-511*	Systematic of Ornamental Plants	2+1
FLS-512*	Commercial Production of Loose Flowers	2+1
FLS-513*	Ornamental Gardening and Landscaping	2+1
FLS-514	Turf Grass Management	2+1
	Semester-II	
FLS-521*	Commercial Production of Cut Flowers	2+1
FLS-522*	Breeding of Ornamental Plants	2+1
FLS-523	Protected Cultivation of Flower Crops	2+1
FLS-524	Nursery Management in Ornamental Plants	2+1
	Semester-III	
FLS-531	Seed Production in Flower Crops	1+1
FLS-532	CAD for Landscaping	1+2
FLS-533	Value Addition in Floriculture	2+1
FLS-534	Indoor Plants and Interiorscaping	1+1
FLS-591	Seminar	1+0
	Semester-IV	
FLS-599	Research	0+30

* Core and compulsory courses.

Note: A student has to opt total 20 credit hours from Major Courses.

Syllabus of Major courses of Floriculture and Landscaping**FLS-511 SYSTEMATICS OF ORNAMENTAL PLANTS (2+1)****THEORY****Block I: Nomenclature**

UNIT I: Nomenclature: History, origin, hotspots, classification and nomenclature systems UNIT I

UNIT II: International systems: International Code, Treaties, International and National Organisations, Biodiversity Act, Identification features, descriptors.

UNIT III: Red Book, Registration (NBPGR, PPVFRA, NBA)

Block 2: Families

UNIT I: Families: Description and families and important genera Rosaceae, Asteraceae, Caryophyllaceae, Orchidaceae, Aracaceae, Liliaceae,

UNIT II: Acanthaceae, Palmaceae, Asparagaceae, Malvaceae, Musaceae, Oleaceae, Iridaceae.

Block 3: Molecular techniques

UNIT I: Molecular techniques in modern systematics

PRACTICALS (16)

1. Different nomenclature systems of plants (2)
2. Floral biology and taxonomic description of rose, chrysanthemum, orchids, carnation,

- gerbera, anthurium, marigold, tuberose, Jasmine, China aster, liliun, gypsophila (6).
3. Cryopreservation and tissue culture repository (4)
 4. Molecular techniques (4)

RESOURCES

- Bhattacharya, B. & Johri, B.M. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Publ. House, New Delhi, India. pp.753.
- Dutta, A.C. 1986. *A Class Book of Botany*. Oxford Univ. Press, Kolkata, India. Pandey, B.P. 2013. *Taxonomy of Angiosperms*. S. Chand & Co. pp. 608
- Rajput, C.B.S. & Haribabu, R.S. 2014. *Citriculture*, Kalyani Publ., New Delhi, India. Spencer, R.R., Cross, R. & Lumley, P. 2007. *Plant Names*. 3rd Ed. *A Guide to Botanical Nomenclature*. CSIRO Publ., Australia., 176 p.
- Vasistha, B.B. 1998. *Taxonomy of Angiosperms*. Kalyani Publ., New Delhi, India.

FLS-512 COMMERCIAL PRODUCTION OF LOOSE FLOWERS (2+1)

THEORY

Block 1: Production management

UNIT I: Scope and scenario: Scope, scenario and importance of loose flowers, constraints and opportunities in loose flower production

UNIT II: Growing environment: Nursery management, pro-tray nursery under shade nets, soil and climate requirement, Field preparation, systems of planting.

UNIT III: Crop management: Soil analysis, soil health card, water and nutrient management, weed management, training and pruning, special horticultural practices such as pinching and disbudding, use of growth regulators, physiological disorders and remedies, INM, IPM and IDM.

UNIT IV: Crop regulation: Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

Block 2: Post harvest management and marketing

UNIT I: Post harvest management: Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packaging and storage

UNIT II: Marketing: Important local markets, Export potential, transportation and marketing, APMC and online trading, institutional support, Crop Insurance

Crops: Rose, jasmine, chrysanthemum, marigold, tuberose, China aster, crossandra, gaillardia, spider lily, hibiscus, Nerium, barleria, celosia, gomphrena, Madar (*Calotropis gigantea*), nyctanthes (Harsingar), Ervatamia (Chandani), ixora, lotus, water lily, Michelia (Champa), gardenia, Ixora and balsam.

PRACTICALS (16)

- Identification of species and varieties (1)
- Propagation and nursery management (1)
- Training and pruning techniques (1)

- Fertigation, foliar nutrition, growth regulator application (2)
- Crop protection (2)
- Pinching, disbudding, staking, harvesting techniques (1)
- Post-harvest handling, storage and cold chain (2)
- Project preparation for regionally important commercial loose flowers. crop specific guidelines for project financing (NHB guidelines) (2)
- Cost Economics (2)
- Exposure Visits to fields (2)

RESOURCES

- Arora, J. S. 2010. *Introductory Ornamental Horticulture*. Kalyani Publi. 6th Edition, pp. 230.
- Bhattacharjee, S. K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
- Bose, T. K. Maiti, R.G., Dhua, R.S. & Das, P. 1999. *Floriculture and landscaping*. Naya Prokash, Kolkata, India.
- Bose, T. K. & Yadav, L. P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.
- Chadha, K. & Bhattacharjee, S. K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.
- Chadha, K. L. & Chaudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
- Laurie, A. & Rees, V. H. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur. pp.534.
- Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur. Randhawa, G.S. & Mukhopadhyay, A. 2001. *Floriculture in India*. Allied Publ. pp 660.
- Sheela, V. L. 2008. *Flowers for Trade*. Horticulture Science Series, vol.10, pp. 392. New India Publ. Agency, New Delhi, India.

FLS-513 ORNAMENTAL GARDENING AND LANDSCAPING (2+1)

THEORY

Block 1: Gardens and components

UNIT I: Styles and types of gardens: Historical background of gardening, Importance and scope of ornamental gardening, styles and types of gardens, formal and informal style gardens. English, Mughal, Japanese, Persian, Spanish, Italian, French, Hindu and Buddhist gardens.

UNIT II: Garden components: Garden components (living and non-living): arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, colour wheels, clock garden, bamboo groves, bonsai; Non-living components like- path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, bird baths, sculptures, waterfalls, bridge, steps, ramps, Lawn - genera and species, establishment and maintenance.

UNIT III: Specialized gardens: Specialized gardens such as vertical garden, roof garden, terrace garden, water garden, sunken garden, rock garden, shade garden, temple garden, sacred gardens (with emphasis on native plants), Zen garden.

Block 2: Landscape planning

UNIT I: Principles and elements of landscaping: Basic drawing skills, use of drawing instruments garden symbols, steps in preparation of garden design, programmes phase, design, phase, etc.

Elements and principles of landscape design. Organization of spaces, visual aspects of plan arrangement- view, vista and axis. Principles of circulation, site analysis and landscape, water requirement, use of recycled water

UNIT II: Landscaping for different situations: Urban landscaping, Landscaping for specific situations such as residential, farm houses, institutions, corporate sector, industries, hospitals, roadsides, traffic islands, Children parks, public parks, xeriscaping, airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks. Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening.

PRACTICALS (16)

- Graphic language and symbols in landscaping, study of drawing instruments viz., 'T' square, setsquare, drawing board, etc. (1)
- Identification of various types of ornamental plants for different gardens and occasions (1)
- Preparation of land, planning, layout and planting, deviations from landscape principles (1)
- Case study (1)
- Site analysis, interpretation of map of different sites, use of GIS for selection (1)
- Enlargement from blue print. Landscape design layout and drafting on paper as per the scale (2)
- Preparation of garden models for home gardens, farm houses, industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special types of gardens.(3)
- Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubby borders (2)
- Project preparation on landscaping for different situations, creation of formal and informal gardens (2)
- Visit to parks and botanical gardens (2)

RESOURCES

- Bose, T. K., Chowdhury, B. & Sharma, S. P. 2011. *Tropical Garden Plants in Colour*. Hort. and Allied Publ.
- Bose, T. K., Maiti, R.G., Dhua, R.S. & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.
- Grewal, H. S. & Singh, P. 2014. *Landscape Designing and Ornamental Plants*. Kalyani Publ. Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.
- Misra, R. L. & Misra, S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India.
- Nambisan, K.M.P.1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi, India.
- Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.
- Sabina ,G.T. & Peter, K.V. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency, New Delhi, India.

- Singh, A. & Dhaduk, B. K. 2015. *A Colour Handbook: Landscape Gardening*. New India Publ. Agency, New Delhi, India.
- Valsalakumari, P. K., Rajeevan, P. K., Sudhadevi, P. K. & Geetha C.K. 2008. *Flowering Trees*. New India Publ. Agency, New Delhi, India.
- Woodrow, M. G. 1999. *Gardening in India*. Biotech Books, New Delhi, India.

FLS-514 TURFGRASS MANAGEMENT (2+1)

THEORY

Block 1: Turf industry and turf grasses

UNIT I: Prospects and basic requirement: History, present status and prospects of turf industry; basic requirements, site selection and evaluation, concepts of quality of soil pertaining to turf grass establishment, criteria for evaluation of turf quality.

UNIT II: Types of turf grasses: Types, species, varieties, important breeders, grasses for different locations and conditions and their compatible groupings as per climatic conditions; Turfing for roof gardens.

UNIT III: Operations and management: Preparatory operations; Turf establishment methods such as seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, instant turfing (portable), hydro-seeding, synthetic turfing. Turf management – Irrigation, drainage, nutrition, special practices like aerating, rolling, coring, dethatching, verticutting, soil top dressing, use of plant growth regulators and micronutrients, Turf mowing - mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs, standards for turf, use of recycled water etc.,

Block 2: Turf for different grounds

UNIT I: Making of different sports arenas: Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, residential and public parks, turfing of Govt. & Corporate office gardens, event specific preparation, turf colourants.

UNIT II: Automation: Exposure to different tools, gadgets, machinery used in turf industry.

PRACTICALS (16)

1. Identification of turf grasses and turf machinery (1)
2. Soil preparation, turf establishment methods, provision of drainage (2)
3. Layout of macro and micro irrigation systems (1)
4. Water and nutrient management (2)
5. Special practices – mowing, raking, rolling, soil top dressing, weed management (2)
6. Biotic and abiotic stress management (2)
7. Project preparation for turf establishment (2)
8. Visit to parks, model cricket grounds and golf courses, airports, corporates, Govt. organizations (2)
9. Rejuvenation of lawns (1)
10. Turf economics (1)

RESOURCES

- Aldous, D.1999. *International Turf Management Handbook*. CRC Press. pp.368.
- Beard, J. B. 1972. *Turf Grass Science and Culture*. Pearson. 1st edition, pp.672.
- Chawla, S. L., Patil, S., Patel, M. A., Patel, R. B. & Patel, R. M. 2013. *Turf grass Management*. Published by NAU, Navsari.
- Emmons, R. 2007. *Turf grass Science and Management*. Cengage Learning Publ. 4th edition, pp. 592.
- Nick-Christians. 2011. *Fundamentals of Turf grass Management*. Wiley; 4th Edition, pp. 424.
- Turgeon, A.J.1980. *Turf grass Management*. Reston Publ. Inc.

FLS-521 COMMERCIAL PRODUCTION OF CUT FLOWERS (2+1)

THEORY

Block 1: Production management

UNIT I: Scope and scenario: National and International scenario, importance and scope of cut flower trade, constraints for cut flower production in India.

UNIT II: Growing environment: Soil analysis, soil health card, Growing environment, open cultivation, protected cultivation, soil/media requirements, land preparation, planting methods, influence of light, temperature, moisture, humidity and microclimate management on growth and flowering.

UNIT III: Crop management: Commercial Flower production – Commercial varieties, water and nutrient management, fertigation, weed management, crop specific practices, ratooning, training and pruning, pinching, deshooking, bending, desuckering, disbudding. Use of growth regulators, physiological disorders and remedies, IPM and, IDM

UNIT IV: Flower regulation: Flower forcing and year round/offseason flower production through physiological interventions, chemical regulation, environmental manipulation.

Block 2: Post harvest management and marketing

UNIT I: Post harvest management: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre- cooling, pulsing, packing, storage and transportation.

UNIT II: Marketing: Marketing, export potential, institutional support, Agri Export Zones, 100% Export Oriented units, Crop Insurance

Crops : Rose, chrysanthemum, gladiolus, tuberose, carnation, gerbera, orchids, liliun, anthurium, China aster, alstroemeria, bird of paradise, heliconia, alpinia, ornamental ginger, dahlia, gypsophila, solidago, limonium, stock, cut greens and fillers.

PRACTICALS

1. Identification of varieties (1)
2. Propagation (2)

3. Microclimate management (2)
4. Training and pruning techniques (1)
5. Pinching, deshooking, disbudding, desuckering (1)
6. Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application (2)
7. Harvesting techniques, post-harvest handling, cold chain (2)
8. Economics, Project preparation for regionally important cut flowers, crop specific guidelines for project financing (NHB guidelines) (2)
9. Visit to commercial cut flower units (2)
10. Case studies (1)

RESOURCES

- Arora, J.S. 2010. *Introductory Ornamental Horticulture*. Kalyani Publishers. 6th edition, pp. 230.
- Bhattacharjee, S. K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
- Bose, T. K., Maiti, R. G., Dhua, R. S. & Das, P. 1999. *Floriculture and Landscaping*. Prokash, Kolkata, India.
- Bose, T. K. & Yadav, L.P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India. Chadha, K. L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India
- Chadha, K. L. & Chaudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
- Dole, J. M. & Wilkins, H. F. 2004. *Floriculture-Principles and Species*. Prentice Hall. 2nd edition, pp. 1048.
- Larson, R. A. 1980. *Introduction to Floriculture*. New York Academic Press. pp. 628.
- Laurie, A. & Rees V, H. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publications, Jodhpur. pp.534.
- Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publications, Jodhpur.
- Randhawa, G. S. & Mukhopadhyay, A. 2001. *Floriculture in India*. Allied Publ. pp 660.
- Reddy S, Janakiram T, Balaji , Kulkarni S. & Misra RL. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.
- Singh, A. K. 2006. *Flower Crops: Cultivation and Management*. New India Publ. Agency, New Delhi, India. pp. 475.

FLS-522 BREEDING OF ORNAMENTAL CROPS (2+1)

THEORY

Block 1: Principles of Plant Breeding

UNIT I: Principles of plant breeding: Principles of plant breeding; Origin, evolution, distribution, introduction, domestication and conservation of ornamental crops

UNIT II: Intellectual Property and Plant Breeders Rights: Introduction and initiatives in IPR and PBR of ornamental crops.

UNIT III: Genetic mechanisms and inheritance: Breeding objectives, reproductive barriers (Male sterility, incompatibility) in major ornamental crops. Inheritance of important traits, Genetic

mechanisms associated with flower colour, size, form, doubleness, fragrance, plant architecture, post-harvest life, abiotic and biotic stress tolerance/ resistance.

Block 2: Breeding methods

UNIT I: Breeding methods: Breeding methods suitable for sexually, asexually propagated flower crops, self and cross pollinated crops- pedigree selection, backcross, clonal selection, polyploidy and mutation breeding, heterosis and F_1 hybrids.

UNIT II: Role of biotechnology: Role of biotechnology in improvement of flower crops including somaclonal variation, *in vitro* mutagenesis, *in vitro* selection, genetic engineering, molecular markers etc.,

Crops: Rose, chrysanthemum, carnation, gerbera, gladiolus, orchids, anthurium, lily, marigold, jasmine, tuberose, dahlia, gaillardia, crossandra, aster etc., Flowering annuals: petunia, zinnia, snapdragon, stock, pansy, calendula, balsam, dianthus etc. Important ornamental crops like aglaonema, dieffenbachia, hibiscus, bougainvillea, kalanchoe etc.

PRACTICALS

1. Floral biology of important ornamental crops (2)
2. Cytology and cytogenetics (2)
3. Selfing and crossing procedures for important ornamental crops (2)
4. Evaluation of hybrid progenies (2)
5. Induction of mutants through physical and chemical mutagens (2)
6. *In vitro* selection, genetic engineering (2)
7. Induction of polyploidy (2)
8. DUS testing (2)

RESOURCES

Vainstein, A. (Ed). 2002. *Breeding for ornamental crops: Classical and Molecular Approaches*. Springer-Science-Business Media, B.V. Edition 1. pp. 392.

Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Pointer Publ., Reprint, 6 vols, pp. 2065.

Bose, T.K. & Yadav, L.P. 1989. *Commercial flowers*. Naya Prokash, Kolkata, India. Callaway, D. J. & Callaway, M. B. 2009. *Breeding Ornamental Plants*. Timber Press. Revised edition, pp. 359

Chadha, K. L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India. Chadha, K. L. & Choudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.

Chaudhary, R.C. 1993. *Introduction to Plant Breeding*. Oxford & IBH Publ. Misra, R.L. & Misra, S. 2017. *Commercial Ornamental Crops: Cut Flowers*. Kruger Brentt Publisher UK Ltd. pp. 584. Misra, R.L. & Misra, S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd. Singh, B. D. 2016. *Plant Breeding Principles and Methods*. Kalyani Publishers, New Delhi- Ludhiana, India.

Watts, L. 1980. *Flower and Vegetable Plant Breeding*. Unileve

FLS-523 PROTECTED CULTIVATION OF FLOWER CROPS (2+1)

THEORY

Block 1: Principles and types

UNIT I: Prospects and types of protected structures: Prospects of protected floriculture in India; Types of protected structures – Glasshouse/polyhouse, shadenet houses, mist chambers, lath houses, orchidarium, fernery, rain shelters etc., ,

UNIT II: Principles and design: Principles of designing and erection of protected structures; Low cost/Medium cost/High cost structures; Location specific designs; Structural components; Suitable flower and foliage plants for protected cultivation.

Block 2: Growing environment

UNIT I: Control of environment: Microclimate management and manipulation of temperature, light, humidity, air and CO₂; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation, water harvesting, UNIT II: Intercultural operations and crop regulation: Containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, IPM and IDM, Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

UNIT III: Automation and standards: Automation in greenhouses, sensors, solar greenhouses and retractable greenhouses, GAP/Flower labels, Export standards, EXIM policy, APEDA regulations for export, Non-tariff barriers.

Crops: Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Liliium, Limonium, Lisianthus, heliconia, Cala lily, Alstroemeria, *etc.*,

PRACTICALS (16)

- Study of various protected structures (1)
- Design, layout and erection of different types of structures (2)
- Practices in preparatory operations, growing media, soil decontamination techniques (2).
- Microclimate management (2)
- Practices in drip and fertigation techniques, special horticultural practices (2).
- Determination of harvest indices and harvesting methods (1)
- Postharvest handling, packing methods (1)
- Economics of cultivation, Project preparation (2)
- Project Financing guidelines (1)
- Visit to commercial greenhouses (2)

RESOURCES

Bhattacharjee, S. K. 2018. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

Bose, T.K., Maiti, R.G., Dhua, R.S. & Das, P. 1999. Floriculture and Landscaping. Naya Prokash, Kolkata, India.

Bose, T. K. & Yadav, L. P. 1989. Commercial Flowers. Naya Prokash, Kolkata, India. Chadha, K. L. & Bhattacharjee, S.K. 1995. Advances in Horticulture: Ornamental Plants. Vol. XII, Parts 1 & 2. pp.533 & pp.574. Malhotra Publ. House, New Delhi, India. Lauria, A. & Victor, H.R. 2001. Floriculture-Fundamentals and Practices. Agrobios Publ., Jodhpur. Nelson PV. 2011. Green House Operation and Management. Pearson Publ. 7th edition, pp. 624. Prasad, S. & Kumar, U. 2003. Commercial Floriculture. Agrobios Publ., Jodhpur. Randhawa, G.S. & Mukhopadhyay, A. 1986. Floriculture in India. Allied Publ. Reddy, S., Janakiram, T., Balaji T., Kulkarni, S. & Misra, R. L. 2007. Hi- Tech Floriculture. Indian Society of Ornamental Horticulture, New Delhi, India

FLS-524 NURSERY MANAGEMENT FOR ORNAMENTAL PLANTS (2+1) THEORY

Block 1: Nursery Industry and Propagation

UNIT I: Scenario of nursery industry and sexual propagation: Importance and present scenario and status of nursery industry in India and in the world , life cycles in plants, Propagation methods, Factors influencing seed germination of flower crops, dormancy, seed quality, packing, storage, certification, testing. Hormonal regulation of germination and seedling growth.

UNIT II: Asexual propagation: Methods of asexual propagation, rooting of soft and hard wood cutting under mist. Role of Plant growth regulators. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principles and methods, budding and grafting – selection of elite mother plants. Stock, scion and inter stock, relationship – Incompatibility,

UNIT III: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in flower crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro- propagules.

Block 2: Nursery Management

UNIT I: Growing structures: Growing structures like mist chambers, tunnels, lath house, net house, growing media types, soil less culture and containers. Automation in nursery management.

UNIT II: Sanitary and phyto-sanitary issues: Nursery – types, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, PPV&FR act and Quarantine system in India. Important quarantine pests and diseases, sanitary and phyto-sanitary issues threats to nursery Industry.

UNIT III: Standards: Nursery standards, Hi-tech nurseries, garden centers.

PRACTICALS (16)

- i. Anatomical studies in rooting of cutting and graft union (2)
- ii. Identification and production of plug plants, seedlings and saplings (2).
- iii. Preparation of growing media and use of PGRs (2).
- iv. Practice of propagation through specialized structures cuttings, layering, budding and grafting (2)
- v. Case studies (2).
- vi. Micropropagation of ornamental crops and hardening (3).
- vii. Visit to tissue culture labs and nurseries (2)

RESOURCES

- Adriance, G.W. & Brison, F. R. 2000. Propagation of Horticultural Plants. Biotech Books, New Delhi, India.
- Bose, T. K., Mitra, S. K. & Sadhu, M. K. 1991. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash, Kolkata, India.
- Chadha, K. L., Ravindran, P. L. & Leela Sahijram. 2000. Biotechnology in Horticulture and Plantation Crops. Malhotra Publ. House, New Delhi, India.
- Davies, Fred T. Jr., Geneve, R. L., Wilson, S. B., Hartmann, H. T. & Kester, D. L. 2018. Hartmann and Kester's Plant Propagation: Principles and Practices. Pearson Publ. 9th Edition.
- Peter, K.V. 2008. Basics of Horticulture. New India Publ. Agency, New Delhi, India.
- Rajan, S. & Baby, L.M. 2007. Propagation of Horticultural Crops. New India Publ. Agency, New Delhi, India. pp. 251.
- Singh, S.P. 1989. Mist Propagation. Metropolitan Book Co., New Delhi, India.

FLS-531 SEED PRODUCTION IN FLOWER CROPS (1+1)

THEORY

Block 1

UNIT I: Scenario of Seed Industry: Scope, scenario and importance of seed production in flower crops. Constraints in flower seed production. Marketing and economics of flower seeds.

Block 2

UNIT I: Seed production-Methods: Methods of seed production, agrotechniques for production of nucleus, breeder and certified seeds. Harvesting, seed processing, seed priming, seed chain, packaging and storage.

UNIT II: Population improvement: Mass selection, progeny selection. Use of incompatibility and male sterility, maintenance of variety and seed production in flower crops. UNIT III: F1 hybrids: F1 hybrid seed production advantages, steps involved in hybrid seed production, pollination behaviour and isolation, pollination management methods in production of F1/ hybrids in different flower crops

Block 3: Regulations

UNIT I: Seed certification and standards: Seed certification, Seed standards, seed act, plant breeders rights and farmers' rights, Bio safety, handling of transgenic seed crops, importing of seeds and OGL, trade barriers in seed business, sanitary and phytosanitary issues, custom clearance and quarantine.

Crops: Marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, poppy, corn flower, rice flower,

PRACTICALS (16)

- Seed production of open pollinated varieties (2)
- Seed production of cross pollinated varieties (2)

- Steps involved in hybrid seed production (2)
- Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc. (6)
- Visit to seed industry (3)
- Visit to quarantine facility (1)

RESOURCES

Bhattacharjee, S. K. 2018. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

Bose, T.K., Yadav, L.P., Pal, P., Parthasarathy, V.A. & Das, P. 2003. Commercial Flowers. Vol. I & II. Naya Udyog, Kolkata, India.

Davies, Fred T. Jr., Geneve R. L., Wilson S. B., Hartmann, H. T., Kester, D. L. 2018. Hartmann and Kester's Plant Propagation : Principles and Practices. Pearson Publ.9th Edition.

Larson, R.A. & Armitage A. M. 1992. Introduction of Floriculture. International Book Distributing Co., Lucknow, India.

FLS-532 CAD FOR LANDSCAPING (1+2)

THEORY

Block 1: CAD

UNIT II: CAD basics and applications: Principles of integrating the architecture and landscaping, Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, Creating legends for plant and non- plant components, Basics of Photoshop software in garden designing.

UNIT II: 2D drawing: 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects. Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout.

Block 2: ARCHICAD

UNIT I: 3D drawing: 3D drawing methods, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

UNIT II: Dimensioning and visualization: ARCHICAD organization tools, Dimensioning and detailing of designs, Landscape designing softwares and CD ROM for ornamental plant material (TRES, HIMFLORA, CAPSSA, etc), Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

PRACTICALS (32)

- Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments (4).
- Isometric drawings, Using productivity tools (2).
- Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden (4).
- Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD (4).
- Organization, dimensioning, detailing and visualization tools with ARCHICAD (4)
- Using Photoshop package for 3D picture insertion (2)
- Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots (6).
- Exposure visits (4)

RESOURCES

Christine, Wein-Ping Yu. 1987. Computer-aided Design: Application to Conceptual Thinking in Landscape Architecture. amazon.com.

Misra, R. L. & Misra, S. 2012. Landscape Gardening. Westville Publ. House, New Delhi, India

FLS-533 VALUE ADDITION IN FLORICULTURE (2+1)

THEORY

Block 1: Value added products

UNIT I: Scope and scenario: Scope and prospects of value addition, National and global scenario, production and exports. Types of value added products, techniques of value addition including tinting.

UNIT II: Value addition in loose flowers: Value addition in loose flowers and product development- Gulkand, floral tea, rose oil, rose water, Pankhuri, floral dyes, rose sherbet, floral ice creams, sweets, etc.

UNIT III: Floral Arrangements: Selection of containers and accessories for floral products and decorations. Flower arrangement, styles, Ikebana schools (*ikenobo*, *ohara*, *sogetsu* etc), Ikebana- moribana, nagiere, contemporary style.

UNIT IV: Dry flowers: Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; tips for collecting dry flower making, selection of stages for picking of flowers for drying, Techniques in dry flower making – Drying, glycerising, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; petal embedded handmade papers, Packaging and storage. Post drying management including moisture, pests and molds.

Block 2: Extraction of value added products

UNIT I: Essential oils: Essential oils; Selection of species and varieties (including non- conventional species), extraction methods, Packing and storage, Aromatherapy.

UNIT II: Pigments and nutraceuticals: Types of pigments, carotenoids, anthocyanins, chlorophyll, betalains; Significance of natural pigments as nutraceuticals, Extraction methods and applications in food, pharmaceutical and poultry industries.

UNIT III: Dying: Synthetic and Natural dyes, dying techniques, colour retention,

PRACTICALS (16)

1. Practices in preparation of different type of flower arrangements including bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers (4)
2. Techniques in flower arrangement and floral decoration (2)
3. Identification of plants for dry flower making (2)
4. Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot- pourri, wall hangings, button holes, greeting cards, wreaths, etc. (2)
5. Essential oil extraction units (1)
6. Extraction of pigments (2)
7. Visit to dry flower units (2)
8. Economics of value added products (1)

RESOURCES

Bhattacharjee, S. K. 2018. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

Chadha, K. L. & Bhattacharjee, S.K. 1995. Advances in Horticulture: Ornamental Plants. Vol. XII, Parts 1 & 2. pp.533 & pp.574. Malhotra Publ. House, New Delhi, India.

Lauria, A. & Victor, H.R. 2001. Floriculture-Fundamentals and Practices. Agrobios Publ., Jodhpur.

Nowak, J. & Rudnicki, R. M. 1990. Postharvest handling and storage of cut flowers, florist greens, and potted plants. Timber Press, USA. pp. 210.

Prasad, S. & Kumar, U. 2003. Commercial Floriculture. Agrobios Publ., Jodhpur.

Reddy, S., Janakiram, T., Balaji T., Kulkarni, S. & Misra, R. L. 2007. Hi- Tech Floriculture. Indian Society of Ornamental Horticulture, New Delhi, India.

FLS-534 INDOOR PLANTS AND INTERIORSCAPING (1+1)

THEORY

Block 1: Scope, principles and operations

UNIT I: Importance and scope: Importance and scope of indoor plants and Interiorscaping, Indoor plants and Indoor air quality.

UNIT II: Classification and principles: Factors affecting growth, development and flowering of Indoor plants. Classification of indoor plants based on light, temperature, humidity and pollution tolerance, Description and cultivation of various indoor plants. Principles of Interiorscaping, Role in pollution mitigation

UNIT III: Cultural operations: Containers and substrates, preparation of growing media, propagation, training, grooming, nutrition, management of disease, pests and weeds. Maintenance of plants including repotting, foliar nutrition, light exposure and plant rotation. Media standards, Nursery and Export standards for potted plants, Nursery standards.

Block 2: Presentations and marketing

UNIT I: Special gardens: Special gardens including miniature gardens and plant stand. Presentations like dish, terrarium, bottle gardens, hanging baskets, window boxes and Bonsai. UNIT II: Vertical gardens: Vertical gardens- History, planting material, structures, containers, substrate, water and nutrient management, supplemental lighting.

Unit 3: Marketing: Marketing channels, Business models including plant rentals.

PRACTICALS (16)

- a) Identification of important house plants (2)
- b) Media and containers (1)
- c) Propagation (1)
- d) Cultural operations, maintenance and economics of indoor plants (2)
- e) Models for Interiorscaping (2)
- f) Familiarization with different indoor gardens (2)
- g) Making of terrariums, bottle garden, dish garden and their economics (2).
- h) Making of vertical gardens and economics (2)
- i) Exposure visits (2)

RESOURCES

Barbara, P. (2005). The Complete Houseplant Survival Manual. Storey Publ., New Adams.
Randhawa, G.S. & Mukhopadhyay, A. 1986. Floriculture in India. Allied Publ.
Wallach, C. (1995). Interior Decorating with Plants. McMillan Seed Production Co. Inc., New York.

(IV) M.Sc. (Hort.) Post Harvest Management

Major Courses

Course Code	Course Title	Credit hrs
Semester I		
PHM-511*	Postharvest Physiology and Biochemistry of Perishables	2+1
PHM-512*	Principles and Methods of Fruit And Vegetable Preservation	2+1
PHM-513	Functional Foods from Horticultural Produce	2+0
Semester II		
PHM-521*	Postharvest Management of Horticultural Produce	2+1
PHM-522	Packaging and Storage of Fresh Horticultural Produce	1+1
PHM-523*	Processing of Horticultural Produce	2+2
PHM-524	Marketing and Entrepreneurship in Postharvest Horticulture	1+1
Semester III		
PHM-531	Packaging and Storage of Processed Horticultural produce	1+1
PHM-532	Laboratory Techniques in Postharvest Management	1+2
PHM-533	Quality Assurance, Safety and Sensory Evaluation of Fresh and Processed Horticultural Produce	2+1
Semester IV		
PHM 591	Seminar	0+1
PHM 599	Research	0+30

Syllabus of Major courses of Postharvest Management

PHM 511 Postharvest Physiology and Biochemistry of Perishables (2+1)

Theory

Block 1: Biochemistry of perishables

Unit I: Introduction, biochemical structure and composition of fruits, vegetables and ornamentals.

Unit II: Biochemical changes during development and ripening. Structural Deterioration of the Produce-cell wall degradation, change in membrane lipid. Biosynthesis of ethylene and its regulation. Ethylene action and ripening processes, its perception-action and regulation.

Block 2: Postharvest physiology of perishables

Unit I: Determining maturity and maturity indices. Ripening processes: events of ripening and factors affecting them.

Unit II: Physiology of pre-harvest and postharvest; factors affecting shelf-life and quality of fruits, vegetables and ornamentals.

Unit III: Respiration: respiratory climacteric, its significance. Transpiration and water stress during postharvest. Postharvest oxidative stress: active oxygen species, AOS generation, physiological effects on horticultural commodity, control of oxidative injury.

Practical

- Determination of physical parameters like specific gravity, fruit firmness, etc.;
- Determination of physiological loss in weight;
- Determination of chemical constituents like sugar, starch, pigments, Vitamin C, acidity during maturation and ripening in fruits/ vegetables;

- Estimation of ethylene evolved from ripening fruits;
- Delay/ Hastening of ripening by ethylene treatments;
- Determination of firmness, TSS, moisture, Titratable acid, sugar, protein, starch, fats, chlorophyll, carotene, anthocyanin, phenols and tannins;
- Measurement of respiration and ethylene evaluation.

Suggested readings:

1. Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*.
2. Vol-1: General Issues, 1-231p Astral International (P) Ltd., New Delhi
3. Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*.
4. Vol-2: Fruit Crops, 253-561p Astral International (P) Ltd., New Delhi
5. Chadha KL and Pal RK. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-3: Vegetables, Flowers and Plantation Crops, 581-727p Astral International (P) Ltd., New Delhi
6. Hodges DM. 2003. *Postharvest Oxidative Stress in Horticultural Crops*, 1st Edition, ISBN 9781560229636
7. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.
8. Sunil Pareek (Ed.) 2016. *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.
9. Thompson AK. 1995. *Post harvest Technology of fruits and vegetables*. Blackwell Sciences Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
11. Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.
12. Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

Websites

1. Food and Agriculture Organization <http://www.fao.org/home/en/> Respiration in plants <http://ncert.nic.in/ncerts/l/kebo114.pdf>
2. Ethylene biosynthesis and its response <http://www.biologydiscussion.com/plants/hormones-plants/ethylene-biosynthesis-and-its-responses-plant-hormones/25986>

PHM 512 Principles and Methods of Fruit and Vegetable Preservation 2+1

Theory

Block 1: Principles and Methods of Fruit and Vegetable Processing

Unit I: Introduction, Historical development in food processing, type of food and causes for food spoilage. Basic principles of fruits and vegetables processing;

Unit II: Thermal processing, pH classification of foods, heat resistance of microorganism; Heat resistance of enzymes in foods, Spoilage of thermal processed food; Containers – canning, rigid tin plates and cans, aluminium cans, glass containers – types; flexible packaging materials, Composite can, specification, corrosion of cans, heat penetration into containers and methods for determination of process time.

Unit III: Effects of low temperature on fresh commodities and prepared product. Freezing preservation, freezing points of foods, slow and quick freezing, Cryogenic freezing and frozen food storage. Drying and dehydration, sun drying solar dehydration, mechanical drying types of driers, osmotic dehydration.

Unit IV: Food fermentation – alcoholic, acetic and lactic fermentation. Pickling and curing; Effect of salt on food preservation, types of salt cured products. Traditional and new products;

chemical preservation, SO₂, benzoic acid, sorbic acid, antioxidants and antibiotics, newer preservatives. Preservation by controlling water activity – high sugar products, intermediate moisture food, food concentration.

Unit V: Food irradiation, principles, types and sources of radiation, mode of action of ionizing radiation; radiation effect on food constituents and regulation.

Practical:

- Preparation and preservation of fruit based beverages and blended products from fruits and vegetables;
- Evaluation of pectin grade; preparation and quality evaluation of fruit jam;
- Preparation of papain;
- Blanching and its effects on enzyme;
- Preparation of dehydrated vegetables;
- Study of different types of spoilages in fresh as well as processed horticultural produce;
- Study of biochemical changes and enzymes associated with spoilage;
- Sensory evaluation of fresh and processed fruits and vegetables;
- Visit to processing units.

Suggested readings

1. Barret DM, Somogyi LP and Ramaswamy H. Eds. 2005. *Processing Fruits: Science and Technology* (2nd Edition), CRC Press, ISBN 9780849314780.
2. FAO. 2007. *Handling and Preservation of Fruits and Vegetables by Combined Methods for Rural Areas- Technical Manual*. FAO Agricultural Services Bulletin 149.
3. Fellows PJ. 2009. *Food Processing Technology: Principles and Practice* (3rd Edition), Woodhead Publishing, ISBN 9781845692162.
4. Lal G, Siddappa GS and Tandon GL. 1998. *Preservation of Fruits and Vegetables*. ICAR, ISBN 9788171640904.
5. Ramaswamy H and Marcotte M. 2006. *Food Processing: Principles and Applications*. Taylor & Francis.
6. Salunkhe DK and Kadam SS. 1995. *Handbook of Fruit Science and Technology: Production, Composition and Processing*. Marcel Dekker.
7. Srivastava RP and Kumar S. 2014. *Fruit and Vegetable Preservation: Principles and Practices* (3rd Edition), CBS Publishing, ISBN 9788123924373.
8. Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

Websites

1. <http://agriinfo.in/default.aspx?page=topic&superid=2&topicid=2065>
2. <http://www.fao.org/docrep/x0209e/x0209e02.htm>
3. http://www.cstaricalcutta.gov.in/images/CTS%20Fruits_and_Vegetables%20NSQF.pdf

PHM 513 Functional Foods from Horticultural Produce (2+0)

Theory

Block 1: Functional food and importance

Unit I: Functional foods- Introduction, definition, history; Importance, relevance and need of functional foods. Sources and classification of functional foods. Importance of horticultural produce as functional foods. Functional foods derived from fruits, vegetables, medicinal and aromatics.

Unit II: Functional ingredients and their properties. Therapeutic potential and effects of horticultural produce; Herbs, herbal teas, oils, etc. in the prevention and treatment of various diseases. Effect of preservation and processing on functional properties of horticulture produce.

Block 2: Bioactive Compounds

Unit I: Introduction, Classes of bioactive compounds present in fruits and vegetables. Polyphenols: Phenolic acid, Stilbenes, Flavonoids, Lignin, Coumarin, Tannin, etc. –their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing. Alkaloids; Nitrogen Containing Compounds; Sulphur compounds; phytosterols; carotenoids; dietary fibers, etc.–their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing.

Unit II: Mechanism of neuroprotection by bioactive compounds. Techniques of Extraction, purification and concentration of bioactive compounds from fruits and vegetables. Bioactive compound and health benefits Incorporation of bioactive compounds in foods.

Block 3: Nutraceuticals

Unit I: Nutraceuticals- Introduction, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Role of medicinal and aromatic plants in nutraceutical industry. Health benefits of phytoneutraceuticals.

Suggested readings

1. Rosa LA, Alvarez-Parrilla E and Gonzalez-Aguilar GA. 2009. *Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability*, Wiley-Blackwell, ISBN 9780813803203.
2. Senrawat R, Khan KA, Goyal MR and Paul PK. 2018. *Technological Interventions in the Processing of Fruits and Vegetables*, Apple Academic Press, ISBN 9781771885867.
3. Vatter DA. 2016. *Functional Foods, Nutraceuticals and Natural Products: Concepts and Applications*. DEStech Publications, Inc, ISBN 978 1 60595 101 0.
4. Watson RR and Preedy V. 2009. *Bioactive Foods in Promoting Health: Fruits and Vegetables* (1st Edition), Academic Press, ISBN 9780123746283

PHM 521 Postharvest Management of Horticultural Produce (2+1)

Theory

Unit I: History, Importance and scope of Postharvest technology of horticultural produce. Nature and structure of horticultural produce. Pre and Postharvest losses and their causes.

Unit II: Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of sprouting, rooting and discoloration in vegetables.

Unit III: Maturity indices for harvest. Harvesting and harvesting tools. Curing in roots and tubers. Prepackage Operation: Precooling, washing, sorting, grading of horticultural perishables for local markets and export. Postharvest handling of spices, plantation crops, medicinal and aromatic plants. Equipments for washing, sizing, grading.

Unit IV: Pre and Postharvest treatments for extending storage life/ vase life. VHT, irradiation treatment, skin coating, degreening, etc. Prepackaging, Packaging techniques for local market and Standards and specifications for fresh produce.

Unit V: Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

Practical

- Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops;
- Protective skin coating with wax emulsion and pre and Postharvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables;
- Prepackaging of perishables;
- Extension of vase life of cut flowers by use of chemicals and growth regulators;

- Control of sprouting of potato and onion by using growth regulators;
- Study of modern harvesting, sorting and grading equipments;
- Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers;
- Visit to packaging centers;
- Visit to local markets, cooperative organizations, and super markets dealing with marketing of Perishables.

Suggested Reading

1. Bhattacharjee SK and Dee LC. 2005. *Postharvest technology of flowers and ornamental plants*. Pointer publishers, Jaipur.
2. Chattopadhyay SK. 2007. *Handling, transportation and storage of fruit and vegetables*. Gene- Tech books, New Delhi.
3. FAO. 2007. *Handling and Preservation of Fruits and Vegetables by Combined methods for Rural Areas*- Technical Manual. FAO Agr.Ser.Bull., 149.
4. Kader AA. 1992. *Postharvest technology of horticultural crops*. 2nd ed university of California. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.
5. Pruthi JS. 2001 (Reprint). *Major spices of India crop management and Postharvest technology*. ICAR, NewDelhi
6. Stawley J Kays. 1998. *Postharvest physiology of perishable plant products*. CBS publishers. Sudheer KP, Indira V. 2007. *Postharvest Technology of Horticultural Crops*, Peter K.V. (Ed.), New India Publishing Agency, ISBN 9788189422431.
7. Sunil Pareek (Ed.) 2016. *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.
8. Thompson AK. (Ed.) 2014. *Fruit and Vegetables: Harvesting, Handling and Storage* (Vol. 1 & 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040
9. Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing
10. Company, New Delhi, India. ISBN 8173871086. Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.
11. Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.

Websites:

1. Horticulture-Post harvest management CSIR-NISTADS <http://www.nistads.res.in/indiasnt2008/t6rural/t6rur13.htm>
2. Post harvest technology- MANAGE <http://www.manage.gov.in/ftf-itt/prgReports/iihr.pdf> Role of post-harvest management <http://www.fao.org/3/y5431e/y5431e02.htm>

PHM 522 Packaging and Storage of fresh Horticultural Produce (1+1)

Theory

Block 1: Storage Systems

Unit I: Importance of storage of horticultural produce, present status and future scope. Principles and methods of storage – field storage structures and designs for bulk storage of horticultural produce- onion and potato, etc. Evaporative cool chambers. Physiological changes during storage.

Unit II: Refrigerated storage – principles of refrigeration, types of refrigerants, refrigeration equipments. Cold storage rooms – Calculation of refrigeration load. Storage requirements of different fruits, vegetables, flowers. Storage disorder symptoms and control.

Unit III: Controlled or modified atmosphere (CA/MA) storage – principles, uses, structures and equipments, methods and requirements. Effect of CA storage on the physiology of stored produce. Hypobaric storage- principle, uses, and requirements. Storage disorders.

Block 2: Packaging

Unit I: Importance of packaging of fresh and processed horticultural produce, present status and future scope. Gaps in packaging concepts. Packaging requirements of fresh horticultural produce. Packaging patterns and methods. Food packaging systems: Different forms of packaging such as rigid, semi-rigid, flexible forms. Traditional, improved and specialized packages. Paper based packages: corrugated fibre board boxes – raw material and types of boxes. Flexible packaging materials – types and their properties. Consumer and intermediate flexible bulk containers. Testing of flexible packaging material. Barrier properties of packaging materials.

Unit 2: New technology in packaging – stretch wrapping system, vacuum packaging, gas packaging, controlled atmosphere (active and intelligent) packaging, vibra packaging, skin packaging, shrink packaging, form- fill-seal packaging, Packaging machines. Quality control and safety aspects of packaging materials.

Practical

- Study of special storage structures for bulk storage of onion/ potato, etc.;
- Study of storage behavior of different fruits and vegetables in zero energy coolchamber;
- Determination of refrigeration requirements (capacity) for given quantity of fruits and vegetables;
- Study of storage behaviour of different fruits and vegetables in cold room;
- Study of chilling injury and storage disorders;
- Study of shelf-life of fruits and vegetables in modified atmosphere packaging. Visit to special storage structures, cold storage units. Study of types of packaging materials, types of plastic films and their properties;
- Determination of water vapour transmission rate (WVTR) and gas transmission rate (GTR) of packaging material;
- Applications of packaging material for fresh fruits and vegetables, beverages, spice products;
- Determination of shelf-life of fresh products in different types of packages;
- Study of packaging machines – vacuum packaging machine, shrink wrapping machine, double seamer, etc. Visit to packaging unit.

Suggested readings

1. Ahvenainen R. 2003. *Novel Food Packaging Techniques*, CRC Press, ISBN 0849317894.
1. Ahvenainen R. 2001. *Novel Food Packaging Techniques*. CRC.
2. Burg SP (Ed.). 2004. *Postharvest physiology and hypobaric storage of fresh produce*, CABI Publishing, ISBN 0851998011.
3. Chattopadhyaya SK. 2007. *Handling, transportation and storage of fruits and vegetables*. Gene- Tech books, New Delhi.
4. Chandra GopalaRao. 2015. *Engineering for Storage of Fruits and Vegetables*; Academic Press, 1st Edition.
5. Coles R, McDowell D and Kirwan MJ. (Eds.). 2003. *Food Packaging Technology*, Blackwell Publishing, ISBN 1841272213.
6. Mahadevaiah M and Gowramma RV. 1996. *Food packaging materials*. Tata McGraw Hill.
7. Painy FA. 1992. *A handbook of food packaging*. Blackie Academic.
7. Pantastico B. 1975. *Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables*. AVI Publ.
8. Robertson GL. (Ed.). 2010. *Food packaging and shelf life: a practical guide* CRC Press, ISBN 9781420078442.
9. Thompson AK. 2010. *Controlled atmosphere storage of fruits and vegetables* (2nd Edition), CAB International, ISBN 9781845936464.

10. Wilson CL. (Ed.). 2007. *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.

Websites

1. Storage practices and structures UCANR <http://ucanr.edu/datastoreFiles/234-1303.pdf>
2. Low cost storage technologies for preservation-IARI http://www.iari.res.in/download/pdf/story4_eng.pdf

https://energypedia.info/wiki/Cold_Storage_of_Agricultural_Products

PHM 523

Processing of Horticultural Produce

(2+2)

Theory

Block 1: Importance and Thermal processes

Unit I: Processing unit- layout and establishment, processing tools. Quality requirements of raw materials for processing, preparation of raw material, primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.

Unit II: Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectin in processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.

Unit III: Juice extractions, clarification and preservation, recent advances in juice processing technology, application of membrane technology in processing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

Block 2: Processing equipment and enzyme kinetics

Unit I: Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging technique for processed products.

Unit II: Quality assurance and storage system for processed products. Nutritive value of raw and processed products, plant sanitation and waste disposal. Types of horticultural and vegetables wastes and their uses, utilization of by- products from fruits and vegetables processing industries.

Practical:

- Handling of harvesting equipments;
- Determination of physical and thermal properties of horticultural commodities;
- Thermal process calculations;
- Particle size analysis, Storage structure design;
- Numerical problems in freezing, drying, conveying and calculations pertaining to texture and Rheology;
- Handling of heating equipment, pulper, juice extractor, deaerator, juice filters;
- Processing industries waste treatment;
- Working of a canning unit;
- Visit to commercial processing units and storage units.

Suggested readings

1. Karel M and Lund DB. 2003. *Physical Principles of Food Preservation* (2nd Edition), CRC Press, ISBN 9780824740634.
2. Paul Singh R and Heldman DR. 2009. *Introduction to Food Engineering* (4th Edition), Academic Press, ISBN 9780123709004.
3. Rao DG. 2010. *Fundamentals of Food Engineering*, PHI Learning Pvt. Ltd., ISBN 9788120338715.
4. Ratti C. 2008. *Advances in Food Dehydration*, CRC Press, ISBN 9781420052527.

5. Toledo RT. 2007. *Fundamentals of Food Process Engineering* (3rd Edition), Springer, ISBN 9780387290195.
6. Smith PG. 2011. *Introduction to Food Process Engineering*, Springer, ISBN 9781441976611.

PHM 524 Marketing and Entrepreneurship in Post-Harvest Horticulture (1+1)

Theory

- Unit I:** Entrepreneurship – Concept, need for entrepreneurship – Types of entrepreneurs -entrepreneurial opportunities in horticultural processing sector-Government schemes and incentives for promotion of entrepreneurship in processing sector.
- Unit II:** Writing Business Plan- Business Plan Format for Small and micro Enterprises-Generation, incubation and commercialization of business ideas – Environment scanning and opportunity identification.
- Unit III:** Steps in establishment of MSME Enterprise – Planning of an enterprise – Formulation and project report-Meaning – Importance Components and preparation.-Government Formalities and Procedures.
- Unit IV:** Marketing potential of processed products at domestic and international level-Marketing management-Marketing functions, market information and market research-Problems in marketing of processed products- Demand and supply analysis of important processed products- Marketing channels – Marketing strategy (product strategy and pricing strategy)- Supply chain management – Meaning, importance, advantages, supply chain management of important processed products.
- Unit V:** Institutional support to Entrepreneurship Role of Directorate of Industries, District Industries, Centres (DICs), Industrial Development Corporation (IDC), State Financial corporation (SFCs), Commercial banks Small Scale Industries Development Corporations (SSIDCs), Khadi and village Industries Commission (KVIC), National Small Industries Corporation (NSIC), Small Industries Development Bank of India (SIDBI).

Practical

- Consumer Behaviour towards Processed Foods;
- An Empirical Test-Carrying out the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of successful Enterprises;
- Constraints in setting up of horti based industries;
- Field visits to study any one of the Local Financial Institutions to study the MSME Policies;
- Preparation of business plan and proposal writing-Project evaluation techniques;
- Discounted and undiscounted techniques;
- Case studies of successful entrepreneurs.

Suggested readings

1. Adhikary MM. 2014. *Enterprise and Entrepreneurship for Agri-Business Management and Planning*. Daya Publishing House. New Delhi
2. Bhaskaran S. 2014. *Entrepreneurship Development and Management*. Aman Publishing House, Meerut.
3. Choudhury M and Barua N. 2014. *Marketing of Processed Fruit and Vegetable*. Daya Publishing House. New Delhi.
4. Gaur SC. 2012. *Handbook of Agro Food Processing and Marketing*. Agrobios. Jodhpur
- Kadam MM and Bishe RN. 2018. *Textbook on Agricultural Entrepreneurship*. Narendra publishing house. New Delhi.
5. Sudheer KP and Indira V. 2018. *Entrepreneurship and Skill Development in Horticultural Processing*. New India Publishing Agency. New Delhi.

PHM 531 Packaging and storage of Processed Horticultural Produce (1+1)

Theory

Block- 1 Packaging principles and functions

Unit I: Functions of packaging; Type of packaging materials; Selection of packaging material for different foods; Selective properties of packaging film; Methods of packaging and packaging equipment.

Unit II: Mechanical strength of different packaging materials; Printing of packages; Barcodes and other marking; Interactions between packaging material and foods; Environmental and cost consideration in selecting packaging materials.

Unit III: Manufacture of packaging materials; Potential of bio composite materials for food packaging; Packaging regulations; Packaging and food preservation; Disposal of packaging materials.

Unit IV: Metal cans: types, fabrication, lacquering and tin quality. Double seaming technology – defects and causes. Glass containers – types; testing quality – thermal shock resistance, thermal shock breakage, impact breakage.

Unit V: Testing of packaging; Rigid and semi rigid containers; flexible containers; Sealing Equipment. Labeling; Aseptic and shrink packaging; Secondary and transport packaging. Different packaging systems for dehydrated foods, frozen foods, dairy foods, fresh fruits and vegetables.

Practical:

- Testing of packaging material: compression strength/drop test/thermal shock test/ seam evaluation/ seam defects;
- Determination of shelf-life of processed products in different types of packages;
- Study of packaging machines – vacuum packaging machine, shrink wrapping machine, double seamer, etc.;
- Visit to packaging units.

Suggested readings

1. Ahvenainen R. 2001. *Novel Food Packaging Techniques*. CRC
2. Ahvenainen R. 2003. *Novel Food Packaging Techniques*, CRC Press, ISBN 0849317894. Coles R, McDowell D and Kirwan MJ. (Eds.) 2003. *Food Packaging Technology*, Blackwell Publishing, ISBN 1841272213.
3. Joseph H Hotchkiss. 1987. *Food and Packaging Interactions*, (ACS symposium series -365, April 5-10, 1987. American Chemical Society, Washington DC. 1988)
4. Mahadevaiah M and Gowramma RV. 1996. *Food packaging materials*. Tata McGraw Hill. Painy FA. 1992. *A handbook of food packaging*. Blackie Academic.
5. Robertson G. L. Ed. 2010. *Food packaging and shelf life: a practical guide* CRC Press, ISBN 9781420078442.
6. Thompson AK. 2010. *Controlled Atmosphere Storage of Fruits and Vegetables*, CABI Publishing; 2nd revised edition.
7. Wilson CL. (Ed.). 2007. *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.

PHM 532 Laboratory Techniques in Postharvest Management (1+2)

Theory

Block 1: Laboratory Techniques in Postharvest Management

Unit I: Rheological techniques and instrumentation used in food industry. Analysis of food additives like food colour, antioxidants, emulsifier, etc.

Unit II: Analysis of pesticide residues, metallic contaminants, Analysis of food flavours. Aflatoxin.

Unit III: Quality analysis of processed fruits and vegetables, coffee, tea and spices. Identification and enumeration of microbial contaminants.

Unit IV: Principles of chromatography (GC, GCMS, HPLC, LCMS), spectrophotometry (Atomic absorption spectrophotometer, ICAP spectrophotometer), ICP-MS, ICPOES, NMR, ESR, amino acid analyser, flame photometry, electrophoresis.

Unit V: Colour measurement in foods, IRGA, Radio-isotopic techniques. Nondestructive quality evaluation (NDQE) - E-nose, E-tongue, machine vision. Electrophoresis.

Practical:

- Sample preparation for quality analysis. Energy calculation, sample calculations;
- Texture analysis, Rheology of different foods;
- Instrumental colour analysis;
- Sensory evaluation and microbiological examinations of fresh and processed products;
- Estimation of tannin/ phytic acid by spectrometric method;
- Moisture and fat analysis by NIR spectroscopy;
- Separation and identification of sugars in fruit juices;
- Separation and identification of carotenoids by column chromatography;
- Estimation of respiration in fruits and vegetables;
- Flavour profile in essential oils using GC;
- Identification and determination of organic acids by HPLC;
- Capsaicin content and Scoville Heat Units in chillies;
- Heavy metal analysis using atomic absorption spectrometry;
- Residue analysis.

Suggested readings

1. Lundanes E., Reubsaet L and Greibrokk T. 2013. *Chromatography: Basic Principles, Sample Preparations and Related Methods*, ISBN-13: 978-3527336203, Wiley VCH
2. Mark F Vitha. 2016. *Chromatography: Principles and Instrumentation*. John Wiley & Sons, ISBN 9781119270881
3. Suzanne NS. 2010. *Introduction to Food Analysis*, ISBN 978-1-4419-1478-1, Springer.
4. Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill ISBN 9780074518519.
5. Semih Otles (Ed). 2016. *Methods of Analysis of Food Components and Additives (Chemical and Functional Properties of Food Components)* CRC Press, ISBN-13: 978-1138199149

PHM 533 Quality Assurance, Safety and Sensory Evaluation of Fresh and Processed Horticultural Produce (2+1)

Theory

Block 1: Quality Assurance

Unit I: Concept of quality: Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation. Concepts of quality management: Objectives, importance and functions of quality control; Quality management systems in India; Sampling procedures and plans.

Unit II: Food laws and regulations in India, Quality management standards, ISO, BIS, PFA, AGMARK and QMS standards, quality system components and their requirements.

Block 2: Safety

Unit I: Food safety and standards act (FSSA,2006); Strategies for compliance with international agri-food standards; Export specification and with international agri-food standards; Export specification and guidelines by APEDA. Hazard analysis and critical control points (HACCP), design and implementation of an HACCP system, steps in the risk management process. Traceability in food supply chains.

Unit II: Organic Certification, GAP, GMP, TQM. Indian and International quality systems and standard like, CodeX Alimentarius, ISO, etc. Consumer perception of safety; Ethics in food safety.

Block 3: Sensory Evaluation

Unit I: Introduction to sensory analysis; general testing conditions, Requirements of sensory laboratory; organizing sensory evaluation programme. Selection of sensory panellists; Factors influencing sensory measurements; Sensory quality parameters -Size and shape, texture, aroma, taste, colour and gloss; Detection, threshold and dilution tests. Different tests for sensory evaluation– discrimination, descriptive, affective; Flavour profile and tests; Ranking tests.

Unit II: Methods of sensory evaluation of different food products. Designing of experiments. Handling and interpretation of Data. Role of sensory evaluation in product optimization. Relationship between objective and subjective methods. Sensory analysis for consumer evaluation. Computer-aided sensory evaluation of food and beverage.

Practical:

- Analysis for TSS, pH, acidity, sugars, pectic substances, minerals, vitamin C, carotene, alcohol, benzoic acid and SO₂ contents, yeast and microbial examination in processed products;
- Demonstration of measurement of vacuum/ pressure, head space, filled weight, drained weight, cut-out analysis and chemical additives;
- Moisture content, rehydration ratio and enzymatic/ non-enzymatic browning in dehydrated products;
- Analysis of spices for quality parameters. Evaluation of processed products according to FSSAI specification;
- Selection and training of sensory panel;
- Identification of basic taste, odour, texture and colour;
- Detection and threshold tests; Ranking tests for taste, aroma, colour and texture; Sensory evaluation of various horticultural processed products using different scales, score cards and tests, Hedonic testing;
- Estimation of color and texture; optimising a product by sensory analysis;
- Studying relationship between objective and subjective methods.

Suggested readings

1. Amerine MA, Pangborn RM and Rosslos EB. 1965. Principles of Sensory Evaluation of Food. Academic Press.
2. Curtis PA. 2005. *Guide to Food Laws and Regulations*, Wiley-Blackwell, ISBN 9780813819464. DGHS *Manual 8: Manual of Methods of Analysis of Foods-Food Additives*.
3. Curtis PA. 2005. *Guide to Food Laws and Regulations*, Wiley-Blackwell, ISBN 9780813819464. Early R. 1995. *Guide to Quality Management Systems for the Food Industry*, Springer, ISBN 9781461358879.
4. Kemp SE, Hollowood T and Hort J. 2009. *Sensory Evaluation: A Practical Handbook*, Wiley-Blackwell Publisher, ISBN 9781405162104.
5. Krammer A and Twigg BA. 1973. Quality Control in Food Industry. Vol.I, II. AVI Publ.

6. Lawless, Harry T, Heymann and Hildegarde. 2010. Sensory Evaluation of Food: Principles and Practices, Springer, ISBN 9781441964885.
7. Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill ISBN 9780074518519.
8. Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill, ISBN 9780074518519.
9. *The Food Safety and Standards Act, 2006 along with Rules & Regulations 2011*, Commercial Law Publishers (India) Pvt. Ltd.

Websites

1. https://en.wikipedia.org/wiki/Sensory_analysis
2. https://link.springer.com/chapter/10.1007/978-1-4757-5112-3_5
3. <https://www.foodqualityandsafety.com/>

(V) M.Sc. (Forestry) Silviculture and Agroforestry

Major Courses

Course Code	Course Title	Credit hrs
	Semester I	
SAF-511*	Silviculture	2 + 1
SAF-512*	Interactions in Agroforestry Systems	1 + 1
SAF-513	Plantation Forestry	2 + 1
SAF-514	Climate Change and Conservation Silviculture	2 + 0
SAF-515	Nutrient and Weed Management in Production Forestry	1 + 1
	Semester II	
SAF-521*	Forest Biometry	1 + 1
SAF-522*	Agroforestry Systems	2 + 1
SAF-523	Modern Nursery Technologies	1 + 1
SAF-524	Industrial Agroforestry	1 + 1
SAF-525	Trees and Shrubs for Agroforestry	1 + 1
SAF-526	Forest Tree Seed Technology	2 + 1
SAF-527	Crops and Live Stock Management in Agroforestry	2+0
	Semester III	
SAF-531*	Silvicultural Practices	1 + 1
SAF-532	Economics of Agroforestry Systems	2 + 1
SAF-591	Master's Seminar	1 (0+1)
	Semester IV	
SAF-599	Master's Research	0+30

*** Core and compulsory courses.**

Note: A student has to opt total 20 credit hours.

Syllabus of Major courses of Silviculture and Agroforestry

SAF-511 SILVICULTURE

2 + 1

Theory

UNIT I

Forest ecosystems- Introduction to tropical/temperate silviculture. Role of silviculture in forest and wild land management, major forest formations-classification, distribution, composition and structure. Vegetation dynamics- species richness-diversity indices. Vegetation forms of India and their productivity.

Forest ecosystem- structure and functioning, community development, competitive interactions in forest communities, forest succession, concepts and models of succession-Connell-Slatyer models, climax theories, tolerance.

UNIT II

Ecophysiology of tree growth- effect of radiation and water relationship, mineral nutrients and temperature. Forest stand development - stand development, even-aged and uneven-aged stands, age and site quality. Tree architecture and its role in stand management.

UNIT III

Stand density determination-stand density indices-stand density management- density management diagram, silvicultural treatments involved- thinning as a stand management tool, objectives of thinning, effects on growth and yield, thinning effect on economic yield of stands. Forest site quality evaluation-direct and indirect methods.

UNIT IV

Treatment analysis-silvicultural regimes- factors influencing choice of regimes, use of system analysis to determine regimes, models for evaluating silvicultural alternatives, development of silvicultural regimes to suit management objectives, optimum management strategies, silvicultural prescriptions for maximum production regime.

Practical

Visit to forest areas to study forest composition, classification, factors of locality, site quality, form and growth of forest trees- study plant succession- study stand density, changes on productivity- thinning effects.

Suggested Readings

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*. McGraw-Hill Book Company.
Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.
Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors.
Khanna LS. 2015. *Theory and Practice of Indian Silviculture Systems*. Bio-Green Publisher.
Lamprecht. 1986. *Silviculture in the Tropics*. Verlag Paul Parey, Hamburg und Berlin.
Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS. 2016 *Silviculture: Concepts and Applications* (III edition), Kindle Edition, USA.
Pascal. 1988. *Wet Evergreen Forests of the Western Ghats*.
Shepherd KR. 1986. *Plantation Silviculture*. Springer.
Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture- Applied Forest Ecology*. John Wiley & Sons.

SAF 512 INTERACTIONS IN AGROFORESTRY SYSTEMS

1+1

Theory

UNIT I

Tree-crop interphase- biological factors affecting form and function in woody and non-woody plant mixtures. Nature and types of interactions- positive and negative, aboveground and belowground interactions- competition, complementarity in resource sharing.

UNIT II

Method for quantifying interactions, principles of resource capture and utilization of light and water, nutrition and space. Tree-soil-crop interactions- nitrogen fixing trees interactions in agroforestry. Allelopathy. Use of radioisotopes in tree-crop interaction studies. Root distribution of trees and crops-competition and/or complementarity. Animal-tree-crop interaction.

UNIT III

Management options to neutralize negative (competitive) interactions, tree husbandry practices for alleviating competition- tree density manipulation, pruning, mixture of trees and herbaceous crops.

Practical

Different methods for quantifying interactions. Studies on allelopathy. Effect, microclimate modifications, different plant mixtures, tree-soil-crop interactions. Estimation of Land Equivalent Ratio, Estimation of competition indices, Measurement and interpretation of light interception in agroforestry systems, Interpretation of yield responses to shelter, soil water and drainage measurement, transpiration measurement, quantifying root distribution.

Suggested Readings

- Avery MA, Cannel MGR and Ong CK. 2005. Biophysical Research for Asian Agroforestry. Oxford and IBH Publishing Co. Pvt. Ltd.
- Mac Dicken, KG and Vergara NT. 1989. Agroforestry-classification and Management.
- Nair PKR. 1993. An Introduction to Agroforestry. Kluwer Academic Pub.
- Ong CK and P Huxley. 2002. Tree-Crop Interactions- A Physiological approach, CAB International.
- Patra AK. 2013. Agroforestry-Principles and Practices. New India Publishing AGENCY, New Delhi (India).

SAF 513 PLANTATION FORESTRY

2+1

Theory

UNIT I

Role of plantation forestry in meeting the wood demand – status of plantation forestry in India and world. Purpose of plantation, factors determining scale and rate of plantation. Land suitability and choice of species. Preliminary site preparation for establishing plantation. Plantation planning, project formulation and appraisal. Planting programme, time of planting, spacing, pattern and planting methods.

UNIT II

Nutritional dynamics and irrigation of plantation. Mechanization in plantation. Protection and after care of plantation. Pruning and thinning in plantations for quality wood production. Rotation in plantation. Failures of plantations. Impact of interaction and integration of plantation forestry.

UNIT III

Protective afforestation, afforestation of inhospitable sites. Plantation forestry for climate change mitigation- carbon forestry. Ecological factors and long term productivity. Sustainable yield from plantations. Case studies in plantations of Eucalyptus, Casuarina, Poplars, Acacias, Pine, Silver Oak,

Gmelina, Teak, Sandal, Bamboo, etc. Production technology of energy plantations, industrial plantations. Emerging concepts in plantation forestry: mixed plantation, continuous cover forests.

Practical

Analysis of plantation problems in Asia and India. Preparation of plantation calendar –Preliminary arrangement for a plantation programme. Planting geometry and calculation of planting stock. Study of different cultural operations and site preparation for plantation. Studies on wood based industries – problems and prospects. Management of Eucalyptus, Casuarina, Teak, Sal, Poplar, Acacias and Bamboo plantations. Production technology for energy plantations. INM in plantations. Irrigation and plantations. Economics of pulpwood, timber and energy plantations. Study of mixed plantation model.

Suggested Readings

Dwivedi AP. 1993. *Forestry in India*. Surya Publ.

Julius E. 1982. *Plantation Forestry in the Tropics*. Clarendon Press, Oxford.

Kumar V. 1999. *Nursery and Plantation Practices in Forestry*. Scientific Publ.

Luna RK. 1989. *Plantation Forestry in India*. International Book Distributors.

Prakash R, Chaudhari DC and Negi SS. 1998. *Plantation and Nursery Techniques of Forest Trees*. International Book Distributors.

SAF 514 CLIMATE CHANGE AND CONSERVATION SILVICULTURE 2+0

Theory

UNIT I

Global climate change-factors involved, green house gases, potential threats, global carbon cycle and C-budget, carbon sequestration. Forests and climate change: Forest responses and vulnerabilities to climate change mitigation. Status of forests in global climate change. Harnessing Forests for Climate Change Mitigation, International climate negotiation, UNFCCC, IPCC, CoP :LULUCF, REDD++ and CDM.

UNIT II

Silviculture and sustainability-criteria and indicators for sustainable plantation forestry in India-CIFOR guidelines. Silvicultural and stand management strategies for carbon sink maximization and source minimization. Adaptive silviculture for climate change.

UNIT III

Disturbance- natural and anthropogenic, short and long term impacts and their implications. Fire loss estimation in forests. Deforestation and degradation trends at global, national and regional levels. Mega development projects, Road widening projects and conservation of native and threatened species, management and rehabilitation plans.

UNIT IV: Impacts of 'No Green Felling' on stand productivity and health. Restoration forestry-silvicultural treatments for habitat restoration, catchment area treatments, enrichment planting,

Analog forestry for site productivity and carbon value. Expanding forest and tree cover area- TOF sector in India.

UNIT V

Role of canopy in regulating functional inputs to stand: canopy and forest continuum, Continuous Cover Forestry. Silviculture of old growth stands and sacred grooves- their ecological significance and biodiversity values. Carbon sequestration potential of Trees Outside forests (TOFs), homegardens and urban forests.

Suggested Readings

Anderson P and Palik B. 2011. Silviculture for Climate Change. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center.

SAF-515 NUTRIENT AND WEED MANAGEMENT IN PRODUCTION FORESTRY 1+1

Theory

UNIT I

History of nutrient management in forest nurseries and plantations. Essential nutrient elements and their deficiency. Mechanism of nutrient uptake by plants, functions and translocation/interactions. Concept of nutrient availability.

UNIT II

Climatic and soil conditions causing micronutrient deficiencies in plants. Occurrence and treatment of micronutrient disorders. Evaluation of soil for the supply of micronutrient. Rare and non-essential elements.

UNIT III

Technology and use of complex liquid and suspension fertilizers. Fertilizer use efficiency. Biological nitrogen fixation and bio-fertilizers. Farm yard manure and other organic fertilizers. Mycorrhizal associations and their significance. Economic implications of nutrient management. Importance of renewable wastes and their recycling.

UNIT IV

Principles of weed control. Methods of weed control-cultural, biological, mechanical and chemical. Herbicide/weedicide classification, properties and their application.

Practical

Methods of soil and plant analysis. Preparation of nutrient solutions. Practical application of fertilizers. Study of fertilizer response and diagnosis of deficiency symptoms. Fertilizer testing and pot experiments. Nursery inoculation techniques of bio-fertilizers. Methods of application of formulated products-seed treatment, root dip, suckers treatment, soil application, foliar application and combination of different methods. Important weeds in forest nurseries and plantations. Control of weeds.

Suggested Readings

Allen V and Barker. 2007. *Handbook of Plant Nutrition*. Pilbeam London.
Dinesh Kumar, Sanjay Chowdhary and Rajvir Sharma. 2011. *Weed Management: Principles and Practices*. Narendra Publishing House.
Gupta OP. 2011. *Modern Weed Management*. Agrobios, New Delhi (India).
Rajaram C. 2012. *Hand book of Plant Nutrition*. NehaPublishers& Distributors.
Rammoorthy and Subbian P. 2012. *Weed Management*. Agrotech Publishing Academy, Udaipur (India).

SAF-521

FOREST BIOMETRY

1+1

Objective

To develop understanding of students about tree and stand measurements, forest inventory and yield concepts.

Theory

UNIT I

Measurement of tree parameters. Determination of tree age and dendrochronology for growth history and climate change studies.

UNIT II

Estimation of volume, growth and yield of individual tree and forest stands. Preparation of volume tables. Application of yield and stand tables.

UNIT III

Forest inventory, sampling methods adopted in forestry, Use of GIS in forest inventory. Quantification of regeneration and stand establishment. Measurement of crown density and crown ratios. Simulation techniques. Growth and yield prediction models – their preparation and applications.

Practical

Calculations of volume of felled as well as standing trees. Volume table preparation. Application of different sampling methods. Preparation of yield and stand table. Quantification of regeneration and stand establishment. Measurement of crown density and crown ratios. Crown profiling of trees and stand. Dendrochronological studies.

Suggested Readings

Chaturvedi AN and Khanna LS. 1994. *Forest Mensuration*. International Book Distributor.
Ram Parkash 1983. *Forest Surveying*. International Book Distributor.

Sharpe GW, Hendee CW and Sharpe WE. 1986. *Introduction to Forestry*. McGraw-Hill.
Simmons CE. 1980. *A Manual of Forest Mensuration*. Bishen Singh Mahender Pal Singh, Dehradun.

SAF-522 AGROFORESTRY SYSTEMS

2+1

Theory

UNIT I

Agroforestry: objectives, importance, potentials and limitations for implementations. Land capability classification and land evaluation. Basis of classification of agroforestry systems and principles, indigenous vs. exotic, intraspecific variations, crown architecture of tropical/temperate trees. Ideotype concept for selection of multipurpose trees. Nitrogen fixing trees. Overview and case studies of different agroforestry systems.

UNIT II

Structural and functional attributes of agroforestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, silvopastoral systems, shelter-belts and windbreaks, energy plantations and home gardens.

UNIT III

Role of trees in soil productivity and conservation– micro-site enrichment- litter and fine root dynamics, Nitrogen fixation and nutrient pumping. Soil productivity and management in agroforestry.

UNIT IV

Community forestry and social forestry, linear strip plantations.

UNIT V

Trends in agroforestry systems research and development, Diagnosis and Design –PRA-RRA tools in agroforestry problem diagnosis.

UNIT VI

Climate Change mitigation and adaptation through agroforestry- climate negotiations- LULUCF-agroforestry options.

Practical

Survey and analysis of land use systems in the adjoining areas. Study of tree crown architecture. Design and plan of suitable models for improvement. PRA-RRA tools in agroforestry problem diagnosis.

Suggested Readings

Buck LE, Lassoie, Fernandes ECM 1999. *Agroforestry in Sustainable Agri. Systems*. CRC Press.

- Kumar BM and Nair PKR. 2006. *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry*. Springer publication.
- Kumar BM and Nair PKR. 2013. *Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges (Advances in Agroforestry)*. Springer publication.
- Nair PKR and Latt 1998. *Directions in Tropical Agroforestry Research*. Kluwer.
- Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer
- Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Pub.
- Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.
- Peter Huxley. 1999. *Multiple Cropping with Woody and Non-Woody Plants*. John Wiley and Sons Ltd, Oxford, United Kingdom.
- Tejwani KG. 1994. *Agroforestry in India*. Oxford & IBH Publishing Co. Pvt Ltd.
- Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development Foundation.
- Young A. 1997. *Agroforestry for Soil Management*. CABI.

SAF-523

MODERN NURSERY TECHNOLOGIES

1+1

Theory

UNIT I

Introduction and importance of nursery. Types of nurseries-temporary and permanent, bare root, containerized and clonal nursery. Bare root nursery- nursery soil and water management, bed preparation, pre-sowing seed treatments, seed sowing and intermediate operations viz., pricking, watering, fertilization, weeding and hoeing.

UNIT II

Physiology and nursery environment interaction affecting seedling growth. Root culturing techniques. Containerized nursery - type and size of containers including root trainers, selection of growing medium. Types of green house and mist chamber for propagation.

UNIT III

Vegetative propagation - importance, selection of superior genotypes, Advanced methods of propagation, containers, growing media, fertilizers, sanitation and management in vegetative propagation. Special requirement for clonal propagation. Propagation Structures and Management,

UNIT IV

Clonal propagation: miniclinal and micro cuttings technology. Vegetative propagation of bamboos and canes. Factors affecting rooting of cuttings. Lifting windows. Important forest nursery pests and diseases and their management. Seedling quality assessment, grading, packaging, storing and transportation.

Practical

Introduction and identification of modern equipments and tools used in nursery. Pre-sowing seed treatments. Preparation of nursery beds and growing media for containerized nursery. Sowing of seed and other intermediate operations. Preparation and planting of cuttings. Use of vegetative

propagation methods such as budding, grafting and layering. Miniclonal and microcutting technology. Use of plant bio-regulators for rooting. Assessment of seedling quality. Maintenance of nursery records. Identification of nursery insects and diseases and their control measures. Visit to forest nurseries. Nursery practices of commercially important tree species.

Suggested Readings

- Bhardwaj RL and Sarolia DK. 2011. *Modern Nursery Management*. Published by Agrobios Publishing. New Delhi (India).
- Kumar GA and Gopikumar. 2003. *Forest Nursery and Tree Husbandry*.
- Kumar V. 2012. *Nursery and Plantation Practices in Forestry*. Scientific Publishers (India).
- Saini RS, Kaushik N, Kaushik RA and Godara NR. 2012. *Practical Nursery Production*. Agrobios, New Delhi (India).

SAF-524 INDUSTRIAL AGROFORESTRY 1+1

Theory

UNIT I

Role of forests in industrial sector, industrial raw material, demand and supply, indigenous and exotic industrial resources, extent of area, policy and legal issues towards industrial wood plantation. Major wood based industries in India; timber, pulp wood, plywood, matches etc. Raw material requirements and their procurements.

UNIT II

Industrial wood plantations – status in India and different states, preferred species – current plantation management and establishment, propagation and plantation technique, economics of industrial agroforestry, pest and disease management for major industrial wood species, harvesting, reduced impact logging, mechanization.

UNIT III

Supply chain; definition, concept, supply chain network, logistic activities, Marketing system; marketing type and channel, price patterns of various industrial wood agroforestry plantations. Contract farming: concept and methods, contract tree farming system in India. Industrial experiences– price support system – constraints. Corporates in industrial agroforestry: International and National corporate, success stories. Corporate social responsibilities. Tree insurance.

UNIT IV

Impacts of industrial agroforestry – ecological impacts; climatic, edaphic and biotic– carbon sequestration. Carbon storage potential of industrial agroforestry and carbon trading mechanism of industrial agroforestry, socio-economic impacts–clean development mechanism. Certification of industrial plantations.

Practical

Study of various wood based industries. Study on raw material requirement and sourcing of plywood, pulp and paper, matchwood, timber processing. Biomass power generation industries. Value addition technology of various wood products. Industrial wood plantations – economics and impact assessment.

Suggested Readings

Cosasalter C and C Pye-Smith. 2003. *Fast Wood Forestry - Myths and Realities*. CIFOR. Bogor, Indonesia. 50p.

Mehta T. 1981. *A Hand Book of Forest Utilization*. International Book Distributors, Dehradun.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic publishers.

Parthiban KT, Umarani R, Umesh Kanna S, Sekar I, Rajendran P and Durairasu P. 2014. *Industrial Agroforestry : Perspectives and Prospectives*. Scientific Publishers.

Tejwani KG. 1994. *Agroforestry in India*. Oxford and IBH publishing Co., New Delhi.

SAF-525 TREES AND SHRUBS FOR AGROFORESTRY 1+1

Theory

UNIT I

Introduction, importance of woody elements in agroforestry systems, their role in biomass production. Suitability of species for different purposes. Multipurpose trees in agroforestry systems. Fodder from trees/shrubs and their nutritive value, propagation techniques.

UNIT II

Role of nitrogen fixing trees/ shrubs. Choice of species for various agro-climatic zones for the production of timber, fodder, fuel wood, fibre, fruits, medicinal and aromatic plants. Generic and specific characters of trees and shrubs for agroforestry.

UNIT III

Fruit crop and small timber trees and their need and relevance in agroforestry, trees suitable for various assemblage and their planting plan in different agroclimatic zones and agroforestry system. Intercropping in fruit orchards like Apple, Walnut, Jack fruit, Mango, Sapota, Pomegranate, Orange, Citrus, Guava etc. Modification in tending and pruning operations and canopy management. Fertility management, yield and quality improvement.

Practical

Field survey and acquaintance with specialized features of trees, shrubs and fruit species and varieties for Agroforestry. Planting plans including wind breaks. Training and pruning of forest trees, shrubs and fruit trees for enhancing production in agroforestry system.

Suggested Readings

Dwivedi AP. 1992. *Agroforestry: Principles and Practices*. Oxford & IBH.

Nair PKR, Rai MR & Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer.
Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.
Srivastava KK. 2007. *Canopy Management of Fruit Crops*, IBD.
Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development Foundation.

SAF-526 FOREST TREE SEED TECHNOLOGY

2+1

Theory

UNIT I

Introduction, trends and development in tropical, sub-tropical and temperate forestry and their influence on seed demand. Seed problems, limiting factors in tree propagation and afforestation.

UNIT II

Reproductive biology of seed plants - development and maturation of seed bearing organs and seeds - morphology of fruit and seed - seed dispersal - ecological fruit and seed types- seasonality and periodicity of flowering and fruiting - reproductive age - influence of external factors on seed production. Seed structure and chemical composition – development and maturation – germination – breakdown of storage products – endogenous hormonal regulation – effect of stimulators and inhibitors– dormancy – its causes and breakage specific problems of seeds of woody plants.

UNIT III

Determining maturity indices. Factors influencing choice of collection methods. Methods of seed collection and processing. Storage methods – loss of viability during storage. Dormancy and pre-treatment. Germination and seedling establishment and seed testing techniques.

UNIT IV

Quality seed production technologies - seed certification.

UNIT V

Eco-physiological role of seed storage. Classification of seed storage potential. Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Storage of orthodox, recalcitrant and intermediate seeds, Fumigation and seed treatment.

Practical

Identification of forest seeds. Seed sampling, different storage methods, Seed quality testing-purity, viability and germination, collection and processing of seeds/ fruit. Tests of viability viz., cutting, hydrogen peroxide, excised embryo, tetrazolium, seed health testing primarily to the presence or absence of disease-causing organisms such as fungi, bacteria, virus and animal pests, recording, calculation and use of results of seed treatment.

Suggested Readings

- Baldwin HI. 1942. *Forest Tree Seed of the North Temperate Regions*. Periodical Experts Book Agency, Delhi.
- Bedell PE. 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publisher Limited.
- Chin HF and Roberts EH. 1980. *Recalcitrant crop seeds*. Tropical Press Sdn. Bhd. Malaysia.
- Dutta M and Saini GC. 2010. *Forest Tree Improvement and Seed Technology*.
- Hong TD and Ellis RH. 1996. *A protocol to determine seed storage behaviour*. IPGRI Technical Bulletin No. 1. (J. M. M. Engels and J. Toll, vol. Eds.) International Plant Genetic Resources Institute, Rome, Italy.
- ISTA. 1993. *International Rules for Seed Testing*. International Seed Testing Association, Zurich, Switzerland.
- Khullar P. et. al. 1992. *Forest Seed*. ICFRE, New Forest, Dehra Dun.
- Leadem CL. 1984. *Quick Tests for Tree Seed Viability*. B.C. Ministry of Forests and Lands, Canada.
- Schmidt L. 2000. *Guide to handling of tropical and subtropical forest seed*. DANIDA Forest Seed Centre, Denmark.
- Umarani R and Vanangamudi K. 2004. *An Introduction to Tree Seed Technology*. IBD, Dehradun.
- Vanangamudi K. 2007. *Advances in Seed Science and Technology*: (Vol. 1. to 5).
- Willan RL. 1985. *A guide to forest seed handling*. FAO Forestry Paper 20/2, DANIDA Forest Seed Centre, Denmark and FAO, Rome.

SAF-527 CROPS AND LIVE STOCK MANAGEMENT IN AGROFORESTRY 2+0

Theory

UNIT I

Choice of inter-crops for different tree species, sowing and planting techniques. Planting patterns, crop geometry, nutrient requirements, and weed management. Management of fodder tree species, thinning, lopping, pruning. Ecological and socio-economic interactions.

UNIT II

Role of tree architecture and its management on system's productivity. Production potentials of fodder based agroforestry systems in different agro-climatic conditions and crop combinations. Importance of cattle, sheep and goat vis-à-vis agro-forestry systems. Feed and fodder resources in agro-forestry systems and live stock management.

UNIT III

Nutrient analysis of forages derived from fodder trees/shrubs. Nutrient requirement for various livestock and their ration computation with agroforestry forages and tree leaves. Forage and tree leaves preservation.

UNIT IV

Calendars for forage crop production in agro-forestry systems including lopping schedules. Optimization of animal production. Animal products technology and marketing.

UNIT V

Integrated Agroforestry Farming System.

Suggested Readings

Bran Powell. 2017. *Livestock Production and Management*. L & K Education.

Kundu SS, Dagar JC, Prakash O, Chaturvedi and Sirohi SK. 2008. *Environment, Agroforestry & Livestock Management*.

SAF-531 SILVICULTURAL PRACTICES

1+1

Theory

UNIT I

Silviculture under changing context of forestry- silviculture and ecosystem management, stand dynamics, silvicultural practices for pure and mixed stand, even aged and uneven aged stand – silvicultural practices for changing climatic conditions.

UNIT II

Silvicultural practices for natural and artificial regeneration – Ecology of regeneration, forest site management- enrichment of site – quality classes and site index models – stand density – spacing and tree growth – forest vegetation management – techniques for early stand growth- tending operations. Biomass allocation: belowground and aboveground. Changing trends in adoption of silvicultural systems.

UNIT III

Stand development – stages- crown dynamics, Crown Competition factor, Maximum crown area, thinning - pruning – response of trees and impact on wood quality, salvage cutting – improvement felling and enrichment planting – management of weeds, Invasive weeds in forests, Silvicultural practices for short rotation forestry- coppice forestry, Continuous cover forestry.

UNIT IV

Site specific selection of tree species. Precision silviculture –silvicultural practices for important fast growing trees and bamboos of India- *Populus species*, *Neolamarkia cadamba*, *Eucalyptus sp.*, *Casuarina sp.*, *Tectona grandis*, *Melia dubia*, *Dalbergia sissoo*, *Gmelina arborea*, *Leucaena leucocephala*, *Ailanthus excelsa*, *Azadirachta indica*, *Swietenia macrophylla*, *Dendrocalamus sp.*, *Bambusa sp.*, - Mechanization of silvicultural practices.

Practical

Visit to different forest sites to study the influence of site factors on composition, Determination of site quality; Studies on stand structure and composition of different forest types; Practicing pruning and its impact on wood quality; Characterizing methods of thinning; Working out intensity of thinning; Study of stand densities in natural forest stand and plantation stand, Afforestation techniques, Wood management techniques for forest tree crops. Planning and designing a tree

planting programme. Exercise on precision silviculture practices. Exercise on mechanized silvicultural practices.

Suggested Readings

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*. McGraw-Hill Book Company.

Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.

Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors.

Khanna LS. 2015. *Theory and Practice of Indian Silviculture Systems*. Bio-Green Publisher.

Lamprecht. 1986. *Silviculture in the Tropics*-Verlag Paul Parey, Hamburg und Berlin.

Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS. 2016 *Silviculture: Concepts and Applications* (III edition), Kindle Edition, USA.

Shepherd KR. 1986. *Plantation Silviculture*. Springer.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture- Applied Forest Ecology*. John Wiley & Sons.

SAF-532 ECONOMICS OF AGROFORESTRY SYSTEMS 2+1

Theory

UNIT I

Basic principles of economics applied to agroforestry. Financial measures. Quantification and valuation of inputs and outputs- direct and indirect methods.

UNIT II

Optimization techniques-Planning, budgeting and functional analysis. Role of time, risk and uncertainty in decision making. Agroforestry budgeting. Risk analysis, re-assessment.

UNIT III

Financial and socio-economic analysis of agroforestry projects. Principles of financial management and harvesting, post harvest handling, value addition, marketing of agroforestry products including benefit sharing.

UNIT IV

Valuation of ecosystem services in agroforestry and payment for ecosystem systems. Bankable agroforestry projects, incentives, tree insurance etc. Certification process in agroforestry based carbon projects, carbon finance etc.

Practical

Exercises on agroforestry production relationships. Preparation of agroforestry based enterprise, partial and complete budgets. Application of various methods in formulation and appraisal of agroforestry projects. Case studies on harvesting, post harvest management and marketing of agro-

forestry products. Valuation of ecosystem services in agroforestry and payment for ecosystem services.

Suggested Readings

- Alavalapati JRR and Mercer D Evan. 2004 *Valuing Agroforestry Systems: Methods and Applications*. Kluwer Academic Publishers.
- Kant S and Janaki A. 2014. *Handbook of Forest Resource Economics*. Publisher: Routledge
- Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer Academic Publishers.
- Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Publishers.
- Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.
- Sullivan Gregory M, Susan Hoke M and Jefferson M. Fox (editors). 1992. *Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July 1991*. Paia, Ill: Nitrogen Fixing Tree Association.
- Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development Foundation.

(VI) M.Sc. (Forestry) Forest Products and Utilization

Major Courses

Course Code	Course Title	Credit Hrs.
	Semester I	
FPU 511	Pulp and Paper Technology	2+1
FPU 512*	Forest Products Laboratory Techniques	0+2
FPU 513	Breeding Techniques and Improvement of Medicinal and Aromatic Crops	2+1
FPU 514*	Wood Identification	0+2
FPU 515	Wood Seasoning and Preservation	2+1
	Semester II	
FPU 521	Applied Wood Technology	2+1
FPU 522	Composite Wood Technology	2+1
FPU 523*	Agro-techniques of Medicinal and Aromatic Crops	2+1
FPU 524	Chemistry and Processing of Medicinal and Aromatic Plants	2+1
FPU 525*	Chemistry of Forest Products and Industries	2+1
FPU 526	Wood Physics	1+1
FPU 527	Production of Medicinal and Aromatic Crops	1+1
FPU 528	Pharmacognosy of Medicinal and Aromatic Plants	1+1
	Semester III	
FPU 531*	Non Wood Forest Products Management	2+1
FPU 532	Wood Chemistry	1+1
FPU 533	Medicinal and Aromatic Plants in Health Care Systems	2 +0

***Compulsory Core Courses**

Syllabus of Major courses of Forest Products and Utilization

FPU 511 Pulp and Paper Technology 2+1

Theory

UNIT I- Raw material used in pulp and paper industries, characteristics and handling.

UNIT II -Pulping process, mechanical, chemical, semi-chemical and biopulping. Pulp bleaching, pulp treatment, defibering, de-knotting, brown stock washing, screening, cleaning, thickening, etc.

UNIT III- Recycled fibers, supplementary pulp treatment and additives. Paper making, paper drying, reeling, external sizing, coating, calendaring, etc.

UNIT IV-Structure of paper, its characterization and measuring strength method, optional and structural properties of paper, Type of paper: coated paper, corrugated containers, printing quality of paper, ageing of paper. Rayon industry.

Practical

- a. Visit to pulp and paper industry;
- b. Study of raw materials, techniques and pulp yield, making of paper and its quality determination.

Suggested Reading

Asuncion J. 2003. *The Complete Book of Paper Making*. Lark books, New York.

Bajpai P. 2018. *Biermann's Handbook of Pulp and Paper*. Vol. 1st:Raw material and pulp making. Elsevier Science, UK.

Biermann C. 1996. *Handbook of Pulping and Paper Making*. 2nd Ed. Academic Press San Diego, New York, Boston, London, Sydney, Tokyo, Toronito.

Britt KW. 1970. *Handbook of Pulp and Paper Technology*. 2nd Ed. Van Nostrand Reinhold Company, New York.

Lavigne JR. 1979. *Instrumentation Applications for the Pulp and Paper Industry*. Miller Freeman Publications. Publishing and Distributors, New Delhi.

Sjostrom E and Alen R (Eds). 1999. *Analytical Methods in Wood Chemistry Pulping and Paper Making*. Springer Series in Wood Science.

Viikari L and Lantto R. 2002. *Progress in Biotechnology*. Vol. 21st. Biotechnology in the pulp and paper industry. 1st Ed. ICBPPI. Elsevier Science.

FPU 512

Forest Products Laboratory Techniques

0+2

Practical

- a. Wood and non-wood product sampling, drying and storage. Estimation of extraneous components of wood. Analysis of volatile compounds;
- b. Estimation of chemical composition of wood samples (hardwoods, softwood and other lignocellulosic material) and ash;
- c. Separation of components by column, paper, and thin layer chromatography. HPLC techniques;
- d. Determination of strength properties of paper and wood composites.

Suggested Reading

Meyland BA and Butterfield BG. 1972. *Three-Dimensional Structure of Wood: A Scanning Electron Microscope Study*. Syracuse University Press.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press, New York.

Skaar C. 1988. *Wood-Water Relations*. Springer Series in Wood Science.

Snyder LR, Kirkland JJ and Glajch JL. 2012. *Practical HPLC Method Development*. 2nd Ed. John Wiley & Sons.

FPU 513 Breeding Techniques and Improvement of Medicinal and Aromatic crops 2+1

Theory

UNIT I - Plant biodiversity, Major objectives of breeding of medicinal and aromatic crops. Plant introduction, domestication and germplasm conservation. Modes of pollination, male sterility, self incompatibility and apomixis. Production and maintenance of pure seeds of medicinal and aromatic plants.

UNIT II - Principles of plant breeding for self pollinated and cross pollinated crops. Selection, Hybridization-techniques and consequences. Heterosis and inbreeding depression. Different plant breeding methods for self pollinated, cross pollinated and asexually propagated crops. Mutation and polyploidy breeding. Distinctiveness, uniformity, stability testing in medicinal and aromatic crops.

UNIT III - Breeding for quality parameters in medicinal and aromatic crops. Achievements and prospects in breeding of important medicinal and aromatic crops- *Rauvolfia serpentina*, *Plantago ovata*, *Cassia angustifolia*, *Ocimum* spp., *Withania somnifera*, *Valeriana* spp., *Opium poppy*, *Gloriosa superb*, *Andrographis paniculata*, *Mentha* spp., *Geranium*, *Cymbopogon* spp., and other important crops.

UNIT IV- Legislation in conservation of medicinal and aromatic plants- IPR issues in medicinal and aromatic plants.

Practical

- a. Identification based on morphological features;
- b. Pollen viability and germination testing;
- c. Stigma receptivity;
- d. Field practice in emasculation, selfing and crossing in different medicinal and aromatic crops;
- e. Determination of mode of pollination and hybridization in different medicinal and aromatic crops.

Suggested Reading

- Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.
- Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publishing House.
- Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.
- Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants*. ICMR.
- Johnson CB and Franz C. 2005. *Breeding Research on Aromatic and Medicinal Plants*. International Book Distributor.
- Sharma R. 2004. *Agrotechniques of Medicinal Plants*. Daya Publishing.
- Singh BD. 2010. *Plant Breeding- Principles and Methods*. Kalyani Publishers.

Practical

- Study of planes of wood, gross features and physical characteristics of important woods;
- Identification of different types of cells and tissues;
- Anatomical studies of soft and hard woods. Anatomical studies of reaction wood;
- Classification of timber using dichotomous key;
- Modern timber identification techniques.

Suggested Reading

- Agarwal VK and Upadhaya SD. 2006. *Agrotechniques of Medicinal and Aromatic Plants*. Satish Serial Publishing House.
- Anoop EV. 1971. *Timber Identification Manual*. Forest Research Institute, Dehradun.
- Dutta JC. 1964. *Botany for Degree Students*. Oxford University Press, Bombay-Calcutta-Madras.
- Govil JN, Pandey J, Shivakumar BG and Singh VK. 2004. *Crop Improvement, Production Technology, Trade Commerce*.
- Lakshman HC and Inchal RF. 2012. *Indigenous Medicinal Plants and their Practical Utility*. Meier E. 2015. *Wood Identifying and Using Hundreds of Woods Worldwide*. Wood database.
- Porter T. 2004. *Wood Identification and Use*. Guild of Master Craftsman, UK.
- Purkayastha SK. 1982. *Indian Woods: Their Identification Properties and Uses*. Controller of Publication.
- Rao R and Juneja KDS. 1971. *A Handbook for Field Identification of Fifty Important Timbers of India*. Manager of Publications.
- Vashishta PC. 1985. *A Text Book of Botany*. S. Chand Publishing Company, New Delhi.

FPU 515

Wood Seasoning and Preservation

2+1

Theory

UNIT I - Wood water relationship, absorption behaviour and wood drying, Refractory and non refractory behaviour of wood, Wood seasoning, types- air, kiln and special seasoning methods like steaming, chemical, high temperature drying, vacuum drying and water conditioning.

UNIT II - Defects of timber- natural, seasoning defects, defects due to machining defects. Effect of defects on utilization.

UNIT III - Detection and diagnosis of discolouration and decay in wood: external decaying agencies- fungi, insects, borer, etc.

UNIT IV- Wood preservation: preservatives and treatment processes. Advantages and safety concern of wood preservatives, fire retardants. Graveyard test and anti-fungal activity of wood. Bio-preservation.

Practical

- Determination of moisture content and swelling coefficients of different woods;
- Comparative studies on air and kiln dried woods;
- Analysis of decayed wood for physical and chemical parameters;
- Treatment of wood with different types of preservatives. Graveyard test.

Suggested Reading

FAO. 2007. *Wood Preservation Manual*. International Book Distributor. Hunt GM. 1967. *Wood Preservation* 3rd Ed.

Mc GRAW-HILL Book Company. Pandey CN and Jain VK. 1992. *Wood Seasoning Technology*. FRI, Dehradun.

Purushotham A, Pande JN and Jadhav. 1959. *Wood Preservation In India*. Manager of Publications.

Winn W. 1919. *Timbers and their Uses*. London George Rotledge & Sons Ltd.

FPU 521

Applied Wood Technology

2+1

Theory

UNIT I -Physical properties of wood-wood density, specific gravity and methods of their determination. Effect of growth on density of wood. Moisture content and its measurement. Effect of sound on wood resonance. Color of wood, phosphorescence, fluorescence and residual luminescence. Thermal properties-conductivity and diffusivity. Electrical properties-conductivity, dielectric constant and current resistivity. Wood permeability.

UNIT II- Mechanical properties-elastic constants, plasticity, Hook's Law, Poisson's ratio, elastic constants, modulus of elasticity, factors affecting strength properties, elastic theory of bending, shear stresses in simple beams, supported beams and cantilevers carrying concentrated and uniformly distributed loads, direct and bending safeworking stresses and their evaluation.

UNIT III- Standard tests of timber specimen's-compression, tensile strength. Mechanics and Rheology of wood, abrasion, brittleness and hardness. Suitability coefficient and indices of different wood species. Vibration properties.

UNIT IV- Effect of environment on mechanical properties of wood. Effect of radiations on strength of wood.

Practical

1. Determination of density, specific gravity, strength, hardness, modulus of elasticity, mechanical properties, thermal conductivity, electrical resistivity and dielectric constant of important domestic and imported timber species.

Suggested Reading

Bodig J and Benjamin AJ. 1993. *Mechanics of Woods and Woods Composites*. Krieger Publish Company.

Brown HP. 1925. *An Elementary Manual on Indian Wood technology*. Central Publication Branch, Government of India, Calcutta.

- Brown HP. 1985. *Manual of Indian Wood Technology*. International Books and Periodicals Supply Service, New Delhi.
- Hill CAS. 2006. *Wood Modification: Chemical, Thermal and other Processes*. John Wiley and Sons Ltd.
- Hoadley B. 2000. *Understanding Wood: A Craftsman's Guide to Wood Technology*. Taunton Press. Newtown, USA.
- Kollmann FFP and Cote WAJ. 1968. *Principle of Wood Science and Technology*. Vol I, Solid wood. George Allen and Unwin Ltd London, Springer-Verlag, Berlin, Heidelberg, New York.
- Panshin AJ and De ZC. 1980. *Textbook of Wood Technology*, 4th Ed. McGraw-Hill. New York.

FPU 522 Composite Wood Technology 2+1

Theory

UNIT I- Introduction to wood modification, its need and scope. Chemical modification of wood (acetylation, reaction with isocyanates, acetates, ethers, epoxides, etc.) Wood impregnation and compregnation, heat stabilization, wood densification.

UNIT II- Modern trends in composite wood. Wood adhesives – types, characteristics and application.

UNIT III- Plywood, laminated wood and inorganic wood composites- their manufacture, characteristics and application.

Practical

- a. Use of different adhesives in plywood;
- b. Study of composite boards, study of anti-shrink efficiency of wood treated with different chemicals;
- c. Impregnation and compregnation of wood with chemicals.

Suggested Reading

- Ansell MP. 2015. *Wood Composites*. Elsevier, Science and Technology.
- Hill CAS. 2006. *Wood Modification: Chemical, Thermal and Other Processes*. John Wiley and Sons Ltd.
- Pizzi A and Mittal KL. 2011. *Wood Adhesives*. CRC Press, New York.
- Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press, New York.
- USDA (U.S. Department of Agriculture). 1999. *Wood Handbook: Wood as an Engineered Material*. US Department of Agriculture, Forest Service. Forest Products Laboratory, Madison, WI.

Theory

UNIT I- Importance of medicinal and aromatic plants in human health, national economy and related industries. Need of cultivation of medicinal and aromatic plants as agricultural crops. Concept of organic farming, GACP and GAP in medicinal and aromatic crops production. Quality concern in plant based drugs.

UNIT II- Introduction and importance, climate and soil requirements, cultural practices, harvesting and yield, important constituents of medicinal plants – Mulhathi, Senna, *Gloriosa superba*, *Valeriana jatamansi*, *Swertia chirayita*, Isabgol, *Rauwolfia serpentina*, *Withania somnifera*, Opium Poppy, *Aloe vera*, Satavar, *Stevia rebaudiana*, Safed Musli, Kalmegh and other important species of the region.

UNIT III- Introduction and importance, climate and soil requirements; cultural practices; harvest and yield; important constituents of aromatic plants – Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, *Tagetes minuta*, Lavender, Rosemary, Patchouli, Geranium and other important species of the region.

Practical

- Morphological identification of listed plants and their economic parts, maturity indices;
- Preparation and layout of nursery and field, methods of seed sowing/ transplantation, cultural operations in MAP crops;
- Raising and harvesting of at least one crop grown in the region;
- Visit to government and private Pharmaceutical units/ Institutes in adjoining areas;
- Visit to large scale herb growing and processing units engaged in commercial cultivation and preparation of purified phytochemical/ standardized extracts;
- Visit to nearby marketing/ trade centres.

Suggested Reading

- Atul CK and Kapur BK. 1982. *Cultivation and Utilization Of Medicinal Plants*. RRL, CSIR, Jammu-Tawi.
- Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publishing House.
- Chopra AK. 2007. *Medicinal Plants: Conservation, Cultivation and Utilization*. Daya Books.
- Chopra RN, Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.
- EIRI Board. 2007. *Handbook of Medicinal and Aromatic Plants: Cultivation, Utilization and Extraction Processes*. Engineers India Research Institute, New Delhi.
- Gunther E. 1975. *The Essential Oils*. Robert, K Krieger Pub. Co, New York.
- Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health*. 1st Ed. Ukaaz Publications.
- Muralia S. 2006. *Medicinal and Aromatic Plants* 1st Ed. Neha Publishers and Distributors.

FPU 524 Chemistry and Processing of Medicinal and Aromatic Plants 2+1**Theory**

UNIT I - Organic compounds and their classification such as aliphatic, aromatic, alkaloids, steroids, terpenoids, glycosides, phenolic compounds, heterocyclic compounds and carbohydrates.

UNIT II - Primary and Secondary plant metabolites and their therapeutic uses of phytoconstituents such as anthraquinones, steroidal and triterpenoidal glycosides, phenolic compounds, lipids, alkaloids and terpenoids.

UNIT III - Basic principles and extraction techniques of different phytoconstituents. Analysis of active principles using TLC, HPLC, Gas chromatography, etc. Quality standards in herbal products. Drug descriptors for medicinal and aromatic plants.

UNIT IV - Postharvest processing-drying, grading and storage. essential oils. Extraction techniques of essential oils and their quality analysis.

Practical

Use of thin layer and column chromatography during extraction and purification of phytopharmaceuticals. Preparation of active constituent enriched extracts. Extraction of Essential oils and their quality evaluation, preparation of concretes and absolutes. Use of HPLC & GC in quality evaluation.

Suggested Readings

Bedi S, Singh T and Vyas SP. 2012. *A Handbook of Aromatic and Essential Oil Plants: Cultivation, Chemistry, Processing and Uses*. Agrobios (India).

Finar IL. 2002. *Organic Chemistry*. Vol. I & II. Pearson Education India.

Raaman N. 2006. *Phytochemical Techniques*. New India Publishing Agency, N. Delhi.

Singh MP and Panda H. 2005. *Medicinal Herbs with their Formulations*. Vol-1st. Daya Publishing House.

Singh S. 2009. *Essentials of Pharmacology*. 2nd Ed. New Age International Publisher.

Wagner H and Bladt S. 2009. *Plant Drug Analysis- A Thin Layer Chromatography Atlas*. Springer (India) Pvt. Ltd

FPU 525 Chemistry of Forest Products and Industries 2+1**Theory**

UNIT I - Importance of forest based industries in relation to Indian economy. Role of Chemistry in relation to forest products.

UNIT II - Classification and description of different forest based industries – pulp and paper, composite wood, furniture, bamboo, sports goods, pencil making, match box and splint making. Use of lesser known wood species for commercial purposes.

UNIT III - Cell wall constituents. Chemistry of cellulose, starch, hemicelluloses and lignin. Extraneous components of wood – water and organic solvent soluble.

UNIT IV - Chemical composition of oleoresin from major pine species. Structural difference among different gums (arabic, ghatti, tragacanth, etc.).

UNIT V - Chemical nature and uses of volatile oils, tannins, katha and cutch and important forest based dyes and pigments.

Practical

- a. Estimation of cell wall constituents – Hemicelluloses and lignin;
- b. Extraction of essential oils, resins and tannins;
- c. Wood pulping. Acetylation of wood;
- d. Visit to nearby forest based industries.

Suggested Reading

Bowyer JL, Shmulsky R and Haygreen JG. 2003. *Forest Products and Wood Science: An Introduction*. 4th Ed. Blackwell Publishing.

Chung and Deborah DL. 2003. *Composite Materials-Functional Materials for Modern Technologies*. Springer, Verlag London.

David AT. 2013. *Forest Products: Advanced Technologies and Economic Analyses*. Elsevier. Eriksson KEL, Blanchette RA and Ander P. 1990. *Microbial and Enzymatic Degradation of Wood and Wood Components*. Springer, Verlag Berlin Heidelberg.

Linskens HF and Jackson JF. 1991. *Essential Oils and Waxes* (Ed.). Springer-Verlag Berlin Heidelberg.

Panda H. 2005. *Hand Book on Specialty Gums, Adhesive, Oils, Rosin And Derivatives, Resins, Oleoresins, Katha, Chemicals with Others Natural Products*. Asia Pacific business press. Inc.

Rojas OJ. 2016. *Cellulose Chemistry and Properties: Fibers, Nanocelluloses and Advanced Materials* (Ed.). Springer International Publishing.

Rowell RM. 2013. *Hand Book of Wood Chemistry and Wood Composites*. CRC press, Taylor and Francis group.

Shackleton S, Shackleton C and Shanley P. 2011. *Non-Timber Forest Products in the Global Context* (Ed.). Springer, Verlag Berlin Heidelberg.

Sharma LC. 2012. *Development of Forests and Forest Based Industries*. M/s Bishen Singh Mahendra Pal Singh.

FPU 526

Wood Physics

1+1

Theory

UNIT I- Wood density, thermal, electrical and acoustic properties of wood. Mechanics and Rheology of wood, elasticity, plasticity and creep (tensile compression and bending strength)

UNIT II - Toughness, torsion, shear, hardness and abrasion strength. Acoustic and acousto-ultrasonics based non-destructive evaluation technique.

Practical

- a. Determination of wood density;
- b. Study of thermal, electrical and acoustic properties of wood;
- c. Determination of tensile and bending properties of wood.

Suggested Reading

- Brown HP. 1925. *An Elementary Manual on Indian Wood Technology*. Central Publication Branch Government of India.
- Dutta AC. 1964. *Botany for Degree Students*. Oxford University Press.
- Franz FP, Kollmann and Wilfred AJC. 1968. *Principle of Wood Science and Technology*. Vol I. Solid wood. George Allen and Unwin Ltd London, Springer-Verlag, Berlin, Heidelberg.
- Franz FP, Kollmann, Kuwnzi E and Stamm AJ. 1975. *Principle of Wood Science and Technology*. Wood based material. Vol. II Springer-Verlag, Berlin, Heidelberg.
- Meyland BA and Butterfield BG (Eds). 1972. *Three-Dimensional Structure of Wood: A Scanning Electron Microscope Study*. Syracuse University Press.

FPU 527

Production of Medicinal and Aromatic Crops 1+1

Theory

UNIT I - Modes of reproduction in MAP crops and their relevance in maintaining genetic purity of crops. Concept of quality seed production and maintenance.

UNIT II - Soil fertility, essential nutrient elements- functions, deficiency symptoms, availability and factors affecting their availability. Soil micro-organisms and their role in organic matter decomposition. Importance of pH and C:N ratio in plant nutrition. Concept of bio-fertilizers and their potential for use in medicinal and aromatic crops.

UNIT III - Essentials of nursery production, criteria of site selection, and types of nursery, establishment of a model nursery. Nursery raising of medicinal plants. Tissue culture technique and *in-vitro* propagation of important MAPs.

UNIT IV -Plant protection measures in medicinal and aromatic crops, Quality parameters of seedlings and nursery stock.

Practical

- a. Asexual/ vegetative reproduction techniques- cutting, budding, layering, etc.;
- Methods of seed collection and storage techniques;
- b. *In-vitro* propagation techniques;
- c. Determination of pH, organic matter and N, P, K from soil.

Suggested Reading

- Atul CK and Kapur BK. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu-Tawi.
- Chopra AK. 2007. *Medicinal Plants: Conservation, Cultivation and Utilization*. Daya Books.
- Chopra RN, Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.
- EIRI Board. 2007. *Handbook of Medicinal and Aromatic Plants: Cultivation, Utilization and Extraction Processes*. Engineers India Research Institute, New Delhi.
- Gunther E. 1975. *The Essential Oils*. Robert, K Krieger Pub. Co, New York.
- Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health*. 1st Ed. Ukaaz Publications.
- Muralia S. 2006. *Medicinal and Aromatic Plants* 1st Ed. Neha Publishers and Distributor

FPU 528**Pharmacognosy of Medicinal and Aromatic Plants 1+1**

UNIT I - History and scope of pharmacognosy, Pharmaceutical products. Classification of natural drugs. Chemical nature of drugs. Pharmacognostic analysis of drug plants based on botanical, chemical and histological features.

UNIT II - Evaluation based on pharmacopoeial standards for both single drugs and compound formulations most commonly used in different systems of medicines.

UNIT III - Pharmacognostic features of Sarpagandha, Jatamansi, Ashwagandha, Turmeric, Punarnava, *Ephedra*, *Gymnema*, Senna, Amla, Gokhru, Isabgol, Black pepper, Banafsha, Arjun or any other commercially species specific to the region.

Practical

- Identification of drugs by morphological characters;
- Physical and chemical tests for evaluation of drugs;
- Gross anatomical studies of Ginger, Ashwagandha, Senna, *Gentiana*, Kalmegh, Sarpagandha, Mulhathi, *Aconitum* species or any other important species relevant to the region.

Suggested Reading

- Atul CK and Kapur BK. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu-Tawi.
- Chopra AK. 2007. *Medicinal Plants: Conservation, Cultivation and Utilization*. Daya Books.
- Chopra RN, Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.
- Cunningham A. 2014. *Applied Ethnobotany: "People, Wild Plant Use and Conservation"*. Taylor & Francis.
- Cupp J and Tracy TS. 2003. *Dietary Supplements: Toxicology and Clinical Pharmacology*. Humana Press.
- Gunther E. 1975. *The Essential Oils*. Robert, K Krieger Pub. Co, New York.
- Gupta K, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants*. Jain SK. 1968. *Medicinal Plants*. National book trust, New Delhi. Oxford & IBH, New Delhi.
- Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health*. 1st Ed. Ukaaz Publications.
- Maheshwari JK. 2000. *Ethnobotany and Medicinal Plants of Indian Subcontinent*. Scientific Publishers, Jodhpur, India.
- Muralia S. 2006. *Medicinal and Aromatic Plants*. 1st Ed. Neha Publishers and Distributors

FPU-531 Non-Wood Forest Products Management 2+1**Theory**

UNIT I - Classification of non wood forest products like gums and resins, katha, dyes, tannins, oils, raw drugs, bamboos, canes and other products.

UNIT II - Technologies for extraction of gums, resins, katha, dyes, tannins, oils, raw drugs and other products.

UNIT III- Utilization of various non wood forest products and their scientific management for processing, value addition, marketing and disposal.

UNIT IV- Quality assessment of important products and their methods for storage. Important industries based on non wood forest products and their management.

Practical

- a. Extraction of resins, gums, katha, dyes, tannins, oils raw drugs, bamboos, canes and other products;
- b. Value addition techniques for these products;
- c. Visit to non wood forest products based industries.

Suggested Reading

Linskens HF and Jackson JF. 1991. *Essential Oils and Waxes* (Ed.). Springer-Verlag Berlin Heidelberg.

Mathe A. 2015. *Medicinal and Aromatic Plants of the World-Scientific, Production, Commercial and Utilization Aspects*. Springer Netherlands.

Panda H. 2005. *Hand Book on Specialty Gums, Adhesive, Oils, Rosin And Derivatives, Resins, Oleoresins, Katha, Chemicals with others Natural Products*. Asia Pacific business press. Inc.

Panshin AJ, Harrer ES and Bethel JS. *Forest Products, their Sources, Production and Utilization*.

Shackleton S, Shackleton C and Shanley P. 2011. *Non-Timber Forest Products in the Global Context* (Ed.). Springer, Verlag Berlin Heidelberg.

FPU 532

Wood Chemistry

1+1

Theory

UNIT I - Chemical composition of wood: Cell wall constituents- cellulose, lignin, hemicellulose, peptic substances, etc.

UNIT II - Volatile oils and extractives, cellulose derivatives and their applications.

UNIT III - Hydrolysis and fermentation of lignocellulosic materials. Pyrolysis and gasification of wood.

Practical

- a. Extraction of cellulose, hemicellulose, lignin, extractives and ash content of wood.

Suggested Reading

Coppen JJW. 1995. *Gums, Resin and Latex of Plant Origin*. Food and Agriculture Organizations, Rome.

Rowe JW. 1989. *Natural Products of Woody Plants*. Springer Series in Wood Science.

Rowell RM. 1984. *The Chemistry of Solid Wood (Advances in Chemistry Series)*. American Chemical Society.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press.
Singh A. 1967. *Plant Physiology*. Readers in Botany, Allahabad University.

FPU 533 Medicinal and Aromatic Plants in Health Care Systems 2 + 0

Theory

UNIT I - Concept of Health Care systems

UNIT II - Brief introduction to Ayurveda, Unani, Sidha, Homeopathy, Allopathy, Naturopathy, Electrohomoeopathy, etc.

UNIT III - Important medicinal plants used in treating various diseases in modern and complementary systems.

UNIT IV - Biological activity of selected medicinal plants. Methods of preparing poultices, decoctions, powders, tinctures, active content rich extracts.

Suggested Reading

- Atul CK and Kapur BK. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu-Tawi.
- Chopra AK. 2007. *Medicinal Plants: Conservation, Cultivation and Utilization*. Daya Books. Chopra RN. Nayar SL and Chopra IC. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.
- Cunningham A. 2014. *Applied Ethnobotany: "People, Wild Plant Use and Conservation"*. Taylor & Francis.
- Gunther E. 1975. *The Essential Oils*. Robert, K Krieger Pub. Co, New York.
- Jain SK. 1968. *Medicinal Plants*. National book trust, New Delhi. Oxford & IBH, New Delhi. Khan IA and Khanum A. 2005. *Medicinal and Aromatic Plants of India; Herbal Wealth for Human Health*. 1st Ed. Ukaaz Publications.
- Maheshwari JK. 2000. *Ethnobotany and Medicinal Plants of Indian Subcontinent*. Scientific Publishers, Jodhpur, India.
- Muralia S. 2006. *Medicinal and Aromatic Plants* 1st Ed. Neha Publishers and Distributors.

(VII) M. Sc. (Forestry) Forest Biology and Tree Improvement

Major Courses

Course Code	Course Title	Credit Hrs.
	Semester I	
FBT-511 *	Applied Forest Tree Improvement	2+1
FBT-512	Tree Seed Orchards	2+1
FBT-513	Forest Genetic Diversity and Conservation	3+0
FBT-514	Clonal Forestry	2+0
FBT-515	Physiology of Woody Plants	2+1
FBT-516	Tree Seed Technology	2+1
	Semester II	
FBT-521*	Quantitative Genetics in Forest Tree Breeding	2+1
FBT-522*	Biotechnology in Forestry	2+1
FBT-523	Forest Ecology and Biodiversity Management	2+1
FBT-524	Reproductive Biology of Forest Trees	2+1
FBT-525	Forest Ecophysiology	2+1
FBT-526	Breeding for Insect Pest and Disease Resistance in Trees	2+1
	Semester III	
FBT-531*	Breeding Methods in Forest Trees	2+1
FBT-591	Master's Seminar	1(1+0)
	Semester IV	
FBT-599	Master's Research	0+30

* Core and compulsory courses

Syllabus of Major courses of Forest Biology and Tree Improvement

FBT-511 Applied Forest Tree Improvement (2+1)

THEORY

UNIT I

General concept of forest tree breeding, tree improvement and forest genetics.

UNIT II

Reproduction in forest trees, dimorphism, pollination mechanism. Pollen dispersal, pollinators. Attractants for pollinators.

UNIT III

Variation in trees, importance and its causes. Natural variations as a basis for tree improvement. Geographic variations – Ecotypes, clines, races and land races.

UNIT IV

Selective breeding methods- mass, family, within family, family plus within family. Plus tree selection for wood quality, disease resistance and agroforestry objectives. Selection strategies and choice of breeding methods and progress in selective breeding in forest trees.

UNIT V

Seed orchards –type, functions and importance, Genetic testing- mating designs and field designs. Progeny and clone testing estimating genetic parameters and genetic gain, clonal and breeding values. Average performance of half sibs and fullsibs. GxE interaction in trees.

UNIT VI

Heterosis breeding: inbreeding and hybrid vigour. Manifestation and fixation of heterosis. Species and racial hybridization. Indian examples – teak, shisham, eucalypts, acacias, poplar, etc.

UNIT VII

Polyploidy, aneuploidy and haploidy in soft and hard wood species. Induction of polyploidy.

UNIT VIII

Elements of biotechnology in tree improvement.

PRACTICAL

- Floral biology, modes of reproduction and modes of pollination in forest trees;
- Estimating pollen viability. Controlled pollination and pollen handling;
- Manipulation of flowering through hormones;
- Identification of ecotypes, races and land-races in natural forest;
- Visit to species, provenance and progeny trials;
- Selection of superior phenotypes;
- Marking of candidate trees, plus trees and elite trees;
- Visit to seed orchards;
- Comparison of parents and their putative hybrids;
- Induction of polyploidy through colchicine treatment;
- In-vitro propagation, study of molecular markers.

SUGGESTED READING

- Dutta M and Saini GC. 2009. Advances in Forestry Research in India, Vol. XXX. Forest Tree Improvement and Seed Technology. International Book Distributors.
- Finkeldey R and Hattemer HH. 2006. Tropical Forest Genetics. Springer.
- Mandal AK and Gibson GL (Eds). 1997. Forest Genetics and Tree Breeding. CBS.
- Sedgley M and Griffin AR. 1989. Sexual Reproduction of Tree Crops. Academic Press
- Surendran C, Sehgal RN and Paramathma M. 2003. Text Book of Forest Tree Breeding. ICAR.
- White TL, Adams WT and Neale DB. 2007. Forest Genetics. CABI, UK.
- Wright JW. 1976. Introduction to Forest Genetics. Academic Press.
- Zobel BJ and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley and Sons.

FBT-512 Tree Seed Orchards (2+1)

THEORY

UNIT I

Importance of genetically improved seed in plantation forestry. Status of seed production among major plantation species. Short term supply of superior seed.

UNIT II

Selection and delineation of seed stands, seed production areas, seed zones, seed ecological zones.

UNIT III

Seed orchard: need, evolving seed orchards, containerized seed, hybrid and research seed orchards; first, second and advanced generation seed orchards. Seed orchard genetics: random mating, gamete exchange and parental balance. Estimation of genetic parameters from seed orchard data. Orchet age and its effect on seed production.

UNIT IV

Importance of progeny testing. Establishment of seed orchards, selection and preparation of orchard site, isolation, orchard size, and designs. Seed orchard management: roguing, silvicultural practices to increase seed yield.

UNIT V

Pest and disease management. Seed collection and record keeping, seed orchard registration and documentation. Importance of seed orchards in gene conservation.

PRACTICAL

- Visits and study of seed orchard designs;
- Estimation of overlap in flowering among genotypes;
- Study of inter and intra-clonal variation in floral, seed characters;
- Effect of girdling on flowering;
- Plant growth regulator application for flower induction;
- Pollen viability/ fertility;
- Assessment of pollen dispersal;
- Supplemental mass-pollination;
- Effects of foliar application of fertilizers on seed set;
- Estimation of genetic parameters for a few traits;
- Estimation of parental balance.

SUGGESTED READING

- Faulkner R. 1975. Seed Orchard Forestry. Commission Bull. No. 34.
- Fins L, Friedman ST and Brotschol JV. 1992. Handbook of Quantitative Forest Genetics. Kluwer.
- Khosla PK. 1981. Advances in Forest Genetics. Ambika Publ., New Delhi.
- Mandal AK and Gibson GL. (Eds.). 1997. Forest Genetics and Tree Breeding. CBS.
- Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. A Text Book of Forest Tree Breeding. ICAR.
- Wright JW. 1976. Introduction to Forest Genetics. Academic Press.
- Zobel BJ and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley & Sons.

FBT-513 Forest Genetic Diversity and Conservation (3+0)

THEORY

UNIT I

Phytodiversity-concept, levels ecosystem. Genetic diversity and differentiation definition, characteristics and importance for tree breeding. Genetic erosion. Techniques to assess genetic diversity. Analysis of karyotypic variation.

UNIT II

Molecular approaches for assessing genetic diversity. Inventory and monitoring biodiversity: sampling strategies for genetic diversity assessments sufficiency of sampling procedures, neutral allele model and optimal allocation of sampling efforts.

UNIT III

Methods of sampling of genetic diversity. Factors influencing levels of genetic diversity in woody plant species. Conservation of genetic diversity Conservation biology and invasive species.

UNIT IV

Laws and policies. Methods for maintenance of conservation: gene banks, arboreta, botanical gardens, breeding populations as repositories of gene conservation. Rare, threatened biodiversity, endangered and endemise plants.

UNIT V

Techniques for survey and assessment of endangered plants. Rarity patterns and endemism. Concept of island biogeography. Managing corridors and natural habitat fragments.

UNIT VI

Monitoring and recovery plans for endangered plants. Plant community reserves. Managing wild flora tourism impacts and eco tourism and urban forestry of rare/ exotic plants. Implications of rarity.

SUGGESTED READING

- Engles JMM, Rao VR Brown AHD and Jackson MT. 2002. Managing Plant Genetic Diversity. CAB International and IPGRI.
- FAO. 1985. Forest Tree Improvement, FAO Publication.
- Fins L, Friedman ST and Brotschol JV. 1992. Handbook of Quantitative Forest Genetics. Kluwer.
- IPGRI. 2004. Forest Genetic Resources Conservation and Management. Vol. 1, 2 and 3.
- Khosla PK. 1981. Advances in Forest Genetics. Ambika Publ., New Delhi.
- Mandal AK and Gibson GL. (Eds.). 1997. Forest Genetics and Tree Breeding. CBS.
- Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. A Text Book of Forest Tree Breeding. ICAR.
- Wright JW. 1976. Introduction to Forest Genetics. Academic Press.
- Zobel BJ and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley and Sons

FBT-514 Clonal Forestry (2+0)

THEORY

UNIT I

Introduction To Clonal Forestry. History Of Clonal Forestry. Clonal Propagation. Clonal Planting. Strategies For Clonal Forestry For Higher Productive Potential.

UNIT II

Juvenility and maturation, rejuvenation and maintainance, regulation of phase changes, markers of phase changes. Breeding strategies using vegetative propagation- selection and breeding for extreme genotypes. Physiological research for higher productivity of clonal forest. Field design, testing and evaluation of clones. Genetic gains from breeding with clonal option. Clonal conservation approaches- management of populations for genetic diversity and gain.

UNIT III

Biotechnological approaches for clonal forestry, Plant tissue culture, micropropagation, Rejuvenation of tissues from mature trees, Testing of Clonal fidelity using molecular markers.

SUGGESTED READING

- Ahuja MR and Libby WJ. 1993. Clonal Forestry I Conservation and Application. Springer
- Ahuja MR. 1992. Micropropagation of Woody Plants: Volume 41 (Forestry Sciences). Springer
- Ahuja MR and Libby WJ. 1993. Clonal Forestry II Genetics and Biotechnology. Springer
- Mandal AK and Gibson GL. 2002. Forest Genetics and Tree Breeding. CBS Publishers New Delhi

FBT-515 Physiology of Woody Plants (2+1)

THEORY

UNIT I

Introduction, Tree physiology. Growth, phases of growth, growth curve, factors affecting growth.- Wood formation.

UNIT II

Plant cell as a structural and functional unit. Organization of cells and tissues, morphogenesis.

UNIT III

Structure of leaves, stem wood, bark and roots in trees. Functions and process in plant growth and development.

UNIT IV

Photosynthesis, structure of photosynthetic tissues and organs, enzyme, energetics and factors influencing photosynthesis. Photorespiration, its mechanisms and significance, factors affecting photorespiration.

UNIT V

Respiration, mechanisms, enzymes, energetics and factors influencing respiration. Respiratory quotient.

UNIT VI

Water relations of trees, absorption, ascent of sap. Translocation of solutes, phloem loading and phloem transport. Transpiration, mechanisms and factors influencing, regulating transpiration, anti transpirants.

UNIT VII

Mineral nutrition. Mineral salt absorption and translocation, deficiency and toxicity of mineral nutrients. Diagnosis of mineral deficiency.

UNIT VIII

The enzymes, nomenclature and classification, structure and compositioned. Mode of action. Phytohormones, auxins, GA, cytokinins, ABA, ethylene. Biosynthesis and biochemical activity of plant hormones. Synthetic plant growth regulators. Growth retardants.

UNIT IX

Nitrogen fixing trees, Nitrogen metabolism. N₂ fixation, physical and biological. Nitrogen assimilation, Amino acid and protein synthesis.

UNIT X

Fat metabolism. Carbohydrate metabolism.

PRACTICAL

- Preparation of growth curves of different tree seedlings;
- Study of structure of leaves;
- Measurement of photosynthesis;
- Observing structure of plant cells and leaves in C₃ and C₄ species;
- Studying stomata in different tree species and working out stomatal frequency;
- Measurement of stomatal size in different tree species;
- Estimation of transpiration rates in different trees;
- Isolation and estimation of chlorophyll;
- Observing xylem vessel size variation in tree species;
- Estimation of plant water status by different methods;
- Nutrient deficiency symptoms in tree seedlings.

SUGGESTED READING

- Dreyer E. 2011. Forest Tree Physiology. University of Minnesota, Elsevier
- Kramer PJ and Kozlowsky TT. 1979. Physiology of Woody Plants. Academic Press.
- Kramer PJ. 1972. Plant and Soil Water Relationships. TMH Edition, Tata McGraw Hill Publ.Co., New Delhi.
- Ksenzhek OS. and Volkov AG. 1998. Plant Energetics. Academic Press, New York.
- Lack AJ and Evans DE. 2001. Plant Biology- Instant Notes. Vina Books Pvt. Ltd., New Delhi.
- Larcher W. 2003. Physiological Plant Ecology. 4th edn, Springer-Verlag, Germany
- Luttge U. 2008. Physiological Ecology of Tropical Plants. Springer-Verlag, Germany

- Malik CP and Srivastava. 2015. Textbook of Plant Physiology. Kalyani Publishers, Mumbai
- Moore TC. 1989. Biochemistry and Physiology of Plant Hormones. 2nd ed. Springer-Verlag, Berlin.
- Noggle RG. and Fritz G.J. 2010. Introductory plant physiology. Sinauer Associates Inc. Publishers, Sunderland
- Pallardy HG. 2008. Physiology of Woody Plants. Elsevier, Amsterdam
- Taiz L and Zeiger E. 2007. Plant Physiology 4th ed. Sinauer Associates Inc. Publishers, Sunderland.
- Zimmerman MH and Brown CL. 1971. Tree structure and Function, Springer Verlag.

FBT-516 Tree Seed Technology (2+1)

THEORY

UNIT I

Trends and development in tropical, sub-tropical and temperate forestry and their influence on seed demand. Seed problems, limiting factors in tree propagation and afforestation.

UNIT II

Ecological fruit and seed types – seasonality and periodicity of flowering and fruiting. Seed structure and chemical composition development and maturation germination breakdown of storage products endogenous hormonal regulation effect of stimulators and inhibitors. Dormancy its causes and breakage specific problems of seeds of woody plants.

UNIT III

Determining optimal harvest maturity indices. Methods of seed collection and processing. Storage methods – loss of viability during storage. Dormancy and pretreatment and seed testing techniques.

UNIT IV

Quality seed production technologies – Seed stand/ seed production area, pollen management in seed orchards. Seed transfer guidelines. Seed certification and legislation.

UNIT V

Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Viability and vigor. Storage of orthodox, recalcitrant and pre-storage intermediate seeds, Fumigation and seed treatment.

UNIT VI

Seed fortification. Seed pelleting.

PRACTICAL

- Identification of forest seed;
- Seed sampling, Seed quality testing- purity, viability and germination;
- Collection and processing of seeds/ fruit. Different storage methods;
- Pretreatment of seed;
- Seed fortification;
- Seed pelleting.

SUGGESTED READING

- Dutta M and Saini GC. 2009. Advances in Forestry Research in India, Vol. XXX. Forest Tree Improvement and Seed Technology. International Book Distributors.
- Khullar P, Thapliyal RC, Beniwal BS, Vakshasya and Sharma A. 1991. Forest Seeds. ICFRE.
- Lars H Schmidt. 2000. Guide to Handling of Tropical and Subtropical Forest Seeds. Danida Forest Seed Centre.
- Mema NP. 1989. Principles of Seed Certification and Testing. Allied Publ.
- Negi SS. 2008. Forest Tree Seeds. International Book Distributors
- Ram Prasad and Kandya RK. 1992. Handling of Forestry Seeds in India. Associated Publ.
- Vanangamudi K. 2007. Advances in Seed Science and Technology, Volume IV. Agrobios (India).

FBT-521 Quantitative Genetics in Forest Tree Breeding (2+1)

THEORY

UNIT I

Historical aspects of quantitative genetics. Inheritance of continuously varying characters, Genetic variance and its partitioning, models of gene action. Multiple factor hypothesis (Nilsson-Ehle (1908) and East (1915) experiments.

UNIT II

Mating systems, population structure in random mating. Hardy Weinberg law, Effect of selection, mutation, migration, genetic drift; on genes and genotypic frequency.

UNIT III

Inbreeding, effects of inbreeding in various populations. Heterosis, causes of heterosis and its utility in various plants.

UNIT IV

Significance and estimation of genetic variance components. Heritability, its estimation by various methods and significance.

UNIT V

Natural selection, fundamental theorem of natural selection (Fisher 1930). Selection responses. Correlation and its utility. Partitioning of correlation into direct and indirect effects.

UNIT VI

Mating design, combining ability, general and specific combining ability and methods of its estimation.

UNIT VII

Genotypic x environment interaction, its significance. Various procedures for the estimation of genotypic x environment interaction.

PRACTICAL

- Exercise on polygenic inheritance;
- Proof that quantitative characters are inherited in Mendelian fashion;

- Estimation of genotypic and phenotypic variance in an experiment, estimation of additive and dominance components of variance through various procedures;
- Mating designs and estimation of components of genetic variance;
- Proof of population genetics law;
- Exercise on calculation of gene and genotypic frequency;
- Estimation of heterosis, estimation of heritability (broad sense and narrow sense) by various methods;
- Genotypic and phenotypic correlation coefficients, partitioning of correlation into direct and indirect effects;
- Estimation of general combining ability and specific combining ability;
- Estimation of genotypic x environment interaction.

SUGGESTED READING

- Acquaah G. 2012. Principal of Plant Genetics and Breeding. John Wiley & Sons, Ltd, UK.
- Kute N and Shinde G. 2016. Principles of Biometrical Genetics. Daya publishing Fins Lauren,
- Friedman ST and Brotschol JV. (Eds.). 1992. Handbook of Quantitative Forest Genetics. Springer, Netherlands.
- Gene Namkoong. 1979. Introduction to Quantitative Genetics In Forestry. Technical Bulletin No. 1588. Forest Service United States Department of Agriculture Washington, D. C.
- Singh RK and Chaudhary BD. 1985. Biometrical Methods in Quantitative genetical Analysis. Kalyani Publishers, New Delhi.

FBT-522 Biotechnology in Forestry (2+1)

THEORY

UNIT I

Introduction. Cloning, need for cloning, problems with cloning. Traditional cloning techniques versus micro-propagation, prospects of micro-propagation in forestry. Techniques procedures and problems in micro propagation, case studies. Protocols for micro-propagation. Preconditioning of explants, surface sterilization, nutritional media, other environmental factors controlling micro-propagation, choice of explants for micro-propagation. Micro propagation of juvenile material. Micro propagation of mature trees; Tissue culture techniques for production of superior planting materials. In-vitro propagation of plants with low sexual reproduction rates, miscellaneous application.

UNIT II

Initiation and maintenance of callus. Organogenesis and somatic embryogenesis – factors influencing somatic embryogenesis-applications in forestry, Somatic seeds, encapsulation techniques. Somaclonal variation, genetic and epigenetic variation, exploitation in forestry. Cell suspension cultures. Anther and pollen cultures. Triploids through endosperm culture, embryo culture. Monoploid production by chromosome elimination. Applications of In-vitro fertilization, isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization. Cryopreservation, storage of plant genetic resources. Production of secondary metabolites by cell cultures. Meristem culture, virus free plants. ; Tissue culture techniques for production of superior planting materials.

UNIT III

Genetic engineering—application in forestry Isozymes, restriction fragment length polymorphisms (RFLPs), randomly amplified polymorphic DNAs (RAPDs) and microsatellites. Genetic fingerprinting, Marker assisted selection. Different PCR techniques: their characteristics, with advantages and disadvantages.

UNIT IV

Quantification of genetic diversity, genotype verification and delineation. Introduction of genes. Promoters and marker genes. Disease resistance, herbicide tolerance and tolerance to salt and other stresses.

PRACTICAL

- Introduction to tissue culture lab;
- Micro propagation: Aseptic techniques;
- Preparation of culture media, formulation of different culture media;
- Induction and maintenance of callus, regeneration of plants from callus, regeneration of plants from embryoids;
- Cell suspension culture;
- Anther and pollen culture. Quantification of tissue culture;
- Isolation and culture of protoplasts;
- Isolation of DNA
- Diversity analysis using Molecular Markers
- Study of PCR techniques
- Tissue culture techniques for production of superior planting materials
- Application of GENALEX ‘bolt on’ for excel, arlequin, PopGene and FSTAT for Wright’s F-statistics and analysis of molecular variance (AMOVA).

SUGGESTED READING

- Bajaj YPS. 1986. Biotechnology in Agriculture and Forestry. Springer Verlag, New York.
- Bonga JM and Durjan J. 1987. Cell and Tissue Culture in Forestry Vol. I & II. Martinus Nijhoff Publishers, Dordrecht.
- Hainer R. 1996. Biotechnology in Forest Tree Improvement. (FAO Bulletin 1994) International Book Distributors. Dehra Dun.
- Muchugi A, Kdu C, Kindt R, Kipruto H, Lemurt S, Olale K, Nyadoi P, Dawson I and Jamnadass R. 2008. Molecular Markers for Tropical Trees, A Practical Guide to Principles and Procedures. ICRAF Technical Manual no. 9. Dawson I and Jamnadass R. eds. Nairobi:World Agroforestry Centre.
- Murphy TM and Thompson WF. 1988. Molecular Plant Development. Prentice Hall, Englewood, Cliffs, New Jersey.
- Russel GE. 1988. Biotechnology of Higher Plants. Intercept publishers, Wimborne, Dorset.
- Russell Haines. 1994. Biotechnology in Forest Tree Improvement with Special Reference to Developing Countries. Food and Agriculture Organization of the United Nations, Rome.

FBT-523 Forest Ecology and Biodiversity Management (2+0)

THEORY

UNIT I

Hierarchy issues in ecology and ecosystem. Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis, forest productivity, ecology of forest landscapes spatial heterogeneity and ecological succession.

UNIT II

Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve). Climate change, Global warming and forests. Green house effect and its consequences. Ozone depletion. Conservation laws and acts. Forest genetics resources of India: timber and non timber species. Survey exploration and sampling strategies Phytogeography and vegetation types of India.

UNIT III

Documentation and evaluation of forest genetical resources (FGR), in situ and ex situ conservation of gene resources. Phytodiversity and its significance to sustainable use. Handling and storage of FGR. Intellectual property rights. Quarantine laws and FGR exchange.

PRACTICAL

- Study of forest community structure and its successional status;
- Estimation of productivity of forest ecosystem; • Study tours to different regions of the state to study forest vegetation;
- Collection and preservation of specimen, Methods of vegetation analysis;
- Measurement of biomass and productivity;
- Quantification of litter production and decomposition;
- Visit to national parks, wildlife sanctuaries, Botanical gardens and arboreta.

SUGGESTED READING

- Avery TE and Burkhardt H. 2001. Forest Measurements. McGraw-Hill Education.
- Barnes BV, Zak DR, Denton SR and Spurr SH. 1998. Forest Ecology. Wiley.
- Jha BC, Pandey BN, Jaiswal K, Katiha PK, Pandey PN and Sharma AP. 2012. Biodiversity: Issues Threats and Conservation. Narendra Publishing House, Delhi.
- Kumar Biju. 2013. Biodiversity and Taxonomy. Narendra Publishing House, Delhi.
- Larocque GR. 2016. Ecological Forest Management Handbook (Applied Ecology and Environmental Management). Taylor & Francis.
- Mahato B, Pandey BN, Singh LB, Pandey PN and Singh RK. 2010. Text Book of Environmental Pollution. Narendra Publishing House, Delhi.
- Mikusiński G, Roberge JM and Fuller R. 2018. Ecology and Conservation of Forest Birds (Ecology, Biodiversity and Conservation). Cambridge University Press.
- Pandey PN. 2009. Biodiversity and Environment Ecology. Narendra Publishing House, Delhi.
- Perry DA, Oren R and Hart SC. 2008. Forest Ecosystems. 2nd ed. Baltimore: Johns Hopkins University Press.
- Young RA and Giese RL. 2003. Introduction to Forest Ecosystem Science and Management. Wiley.

FBT-524 Reproductive Biology of Forest Trees (2+1)

THEORY

UNIT I

Importance and application of reproductive biology in tree breeding. Crop characteristics-growth and development (both vegetative and reproductive).

UNIT II

Floral diversity and pollination. Flower types pollination syndromes and their evolution. Plant – pollinator systems. Diversity of pollination syndromes in selected plant families. Modes of reproduction-sexual, asexual and vegetative and their breeding systems and sex expression, monoecy, dioecy and its evolution.

UNIT III

Floral attractants and rewards biology of floral and extra floral nectaries examples of plant insect interactions involving pollination. Floral characteristics of the main pollination syndromes.

UNIT IV

Fertilization in hardwood and softwood species. Seed dispersal and gene flow.

PRACTICAL

- Sex expression in forest trees;
- Out crossing mechanisms in forest trees;
- Measurement of pollen flow in wind-pollinated and insect-pollinated species;
- Pollen viability and fertility;
- Seed dispersal mechanism.

SUGGESTED READING

- Almeida OJG, Cota K Sánchez JH and Paoli AAS. 2013. The systematic significance of floral morphology, nectaries and sugar nectar concentration in epiphytic cacti of tribes Hylocereeae and Rhipsalideae (Cactaceae). *Persp. Plant Ecol. Evol. Syst.* 15: 255-268.
- Barrett SCH. 2006. Ecology and Evolution of Flowers [electronic resource]. (Eds.) L.D. Harder SCH. Barrett. Oxford Univ. Press, New York, U.S.A.
- Bawa KS and Hadley M. 1990. Reproductive Ecology of Tropical Forest Plants. UNESCO Man and Biosphere Series.
- Briggs and Walters SM. 1984. Plant Variation and Evolution.
- Cláudia Inês da Silva and Helena Maura Torezan Silingardi. 2006. Reproductive Biology of Tropical Plants – International Commission On Tropical Biology and Natural Resources. Encyclopedia of Life Support Systems (EOLSS)
- FAO. 1985. Forest Tree Improvement, FAO Publication.
- Khosla PK. 1981. Advances in Forest Genetics. Ambika Publ., New Delhi.
- Mandal AK and Gibson GL. (Eds.). 1997. Forest Genetics and Tree Breeding. CBS.
- Sedgley and Griffin. 1989. Sexual Reproduction of Tree Crops.
- Spencer C H, Barrett, Robert I, Colautti and Christopher G Eckert. 2007. Plant Reproductive Systems and Evolution during Biological Invasion. Wiley Online Library. (<https://doi.org/10.1111/j.1365-294X.2007.03503.x>).

FBT-525 Forest Ecophysiology (2+1)

THEORY

UNIT I

Forest environment interactions, Forest ecosystems, Geographic and climatic factors. Environmental factors influencing forest growth and productivity. Sun and shade plants.

UNIT II

Influence of temperature, water stress and nutrient availability and disturbance in the forest on tree growth and forest productivity.

UNIT III

Dynamics of forest ecosystems, energy, productivity and biomass. Decomposition and nutrient cycling.

UNIT IV

Stand structure and micro-climate, energy relationships canopy energy balance. Partitioning absorbed energy. Radiation penetration into and absorption by canopies. Air temperature and humidity in forests. Turbulent transfer process above forests.

UNIT V

Transpiration and evapotranspiration from forest canopies. Estimation of ET.

UNIT VI

Stress – avoidance and tolerance mechanisms. Temperature stress – low temperature stress – physiology of resistance to frost. Heat stress, heat injury, heat avoidance and tolerance mechanism. Radiation stress, mechanism of shade tolerance, water logging, physiology of resistance to water logging. Drought stress, salt and ion stress.

PRACTICAL

- Morphological, anatomical and physiological variations between sun and shade plants;
- Estimation of leaf area, LAI;
- Estimation of biomass production of trees of different species;
- Estimation of microclimatic elements as influenced by stand structure; • Estimation of evapotranspiration;
- Measurement of radiation in different types of forest and agroforestry systems.

SUGGESTED READING

- Kozlowski TT, Kramer PJ and Pallardy GS. 1991. The Physiological Ecology of Woody Plants. Academic Press, New York.
- Kramer PJ. 1972. Plant and Soil Water Relationships. TMH Edition, Tata McGraw Hill Publ. Co., New Delhi.
- Ksenzhek OS and Volkov AG. 1998. Plant Energetics. Academic Press, New York.
- Lack AJ and Evans DE. 2001. Plant Biology- Instant Notes. Vina Books Pvt. Ltd., New Delhi.
- Lambers H, Chaplin FS and Pons TL. 1998. Plant Physiological Ecology. Springer, New York
- Larcher W. 2003. Physiological Plant Ecology. 4th edn, Springer-Verlag, Germany
- Luttge U. 2008. Physiological Ecology of Tropical Plants. Springer-Verlag, Germany

FBT-526 Breeding for Insect Pest and Disease Resistance in Trees (2+1)

THEORY

UNIT I

Need for disease resistance in forest trees, Process of infection. Variability in plant pathogens. Types of resistance. Inheritance of resistance. Disease resistance mechanisms in trees, Clonal resistance. Disease resistance breeding techniques. Techniques of isolating resistant genes; developing disease resistant transgenic plants.

UNIT II

History and importance of insect pest resistance, types and mechanism of resistance. Insect-tree relationships. Basis of resistance: Induced resistance and acquired resistance. Defense mechanisms against insects. Factors affecting tree pest resistance. Breeding for insect resistance.

PRACTICAL

- Disease progression in relation to resistance, disease resistance in Clonal plantations and seed orchards, hypersensitivity and its mechanisms, disease resistance screening;
- Screening for insect pest resistance; chemical and morphological characterization of susceptible/ resistance tree species;
- Defence strategies of woody plants.

SUGGESTED READING

- Dube HC. 2014. Modern Plant Pathology, Second Edition. Agribios, Jodhpur (India).
- Harsh NS. 2012. Disease Resistance in Genetic Material in Tree Improvement Programme. Lambert Acad. Publications.
- Heybroek HM, Stephan BR and Weissenberg KV. 1990. Resistance to Diseases and Pests in Forest Trees. IBD, Dehra Dun (India).
- Nair KSS, Sharma JK and Varma RV. 1996. Impact of Diseases and Insect Pest in Forest Trees.
- Parker J. 2008. Molecular Aspects of Plant Disease Resistance. Ann. Pl. Rev., 34. Blackwell Publications UK.
- Ross Wylie F and Martin R Speight. 2012. Insect Pests in Tropical Forestry (2nd Ed.). CABI Tropical Forests.
- Van der Plank JE. 1984. Disease Resistance in Plants. Academic Press Inc., New York. Van der Plank JE. 1982. Host Pathogen Interactions in Plant Disease. Academic Press Inc., New York.
- William M Ciesla. 2010. Forest Entomology-A Global Perspective. Wiley-Blackwell.

FBT-531 Breeding Methods in Forest Trees (2+1)

THEORY

UNIT I

Genetic constitution of tree populations, half-sib, full-sib family in trees. Hardy-Weinberg equilibrium, changes in gene frequency through selection, migration, mutation and population sizes.

UNIT II

Long-term and short-term breeding populations. Selective breeding methods- mass, family, within family, family plus within family. Grading system of plus trees in natural stands and plantations

selection index, regression systems, mother tree selection and subjective evaluation. Selection for different traits.

UNIT III

Genetic testing programmes – mating designs, complete designs – nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs – open pollinated mating and polycross mating. Improvement through progeny testing.

UNIT IV

Experimental designs in genetic testing. Breeding methods for wood quality, diseases and pest resistance, drought and salt resistance. Testing procedures for genetic advancement. Marker assisted selection.

UNIT V

Tree improvement case histories.

PRACTICAL

- Half-sib, full-sib family in trees;
- Grading system of plus trees in natural stands;
- Mating designs, complete pedigree designs – nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs – open pollinated mating and polycross mating;
- Selection for biotic and abiotic stresses.

SUGGESTED READING

- Acquaah G. 2012. Principal of Plant Genetics and Breeding. John Wiley & Sons, Ltd, UK.
- Falconer DS and Mackay TFC. 1995. Introduction to Quantitative Genetics. 4th edition. Longman, Essex
- Mandal AK and Gibson GL. 2002. Forest Genetics and Tree breeding. CBS Publishers
- Namkoong G, Kang HC and Brouard JS 1988. Tree breeding: Principles and Strategies. Springer Verlag, New York.
- Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. A Text Book of Forest Tree Breeding. ICAR.
- White TL and Hodge GR 1989. Predicting Breeding Values with Applications in Forest Tree Improvement. Kluwer Academic Publishers, Boston.
- White TL, Adams WT and Neale DB. 2007. Forest Genetics. CABI
- Wright JW. 1962. Genetics of Forest Tree Improvement. Academic Press.
- Wright JW. 1976. Introduction to Forest Genetics. Academic Press.
- Zobel BJ and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley and Sons

(I) Ph. D. (Hort.) Fruit Science

Major Courses

Course Code	Course Title	
	Semester I	
FSC 611*	Innovative Approaches in Fruit Breeding	3+0
FSC 612*	Modern Trends in Fruit Production	3+0
FSC 613	Recent Developments in Growth Regulation	3+0
FSC 614	Advanced Laboratory Techniques	1+2
	Semester II	
FSC 621	Arid and Dry Land Fruit Production	2+0
FSC 622	Abiotic Stress Management in Fruit Crops	2+1
FSC 623	Biodiversity and Conservation of Fruit Crops	2+1
FSC 624	Smart Fruit Production	2+0
	Semester III	
FSC 691	Seminar-I	0+1
	Semester IV	
FSC 691	Seminar-II	0+1
	Semester V & VI	
FSC 699	Research	0+75

**Compulsory among major courses*

Syllabus of Major courses of Ph.D. (Hort.) Fruit Science

FSC- 611 INNOVATIVE APPROACHES IN FRUIT BREEDING (3+0)

THEORY

Block 1: Introduction

UNIT I: Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits etc.

Block 2: Genetic Mechanisms

UNIT I: Inheritance Patterns and Breeding Systems: Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits.

Block 3: Breeding for Specific Traits

UNIT I: Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance, crop specific traits ; use of apomixis, gene introgression and wide hybridization (alien genes).

Block 4: Fast- Track Breeding

UNIT I: Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops ; fast track breeding – marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing technologies.

CROPS:

Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit, plums, peaches, apricot, cherries, nectarines, nut crops

RESOURCES

Al-Khayari , J., Jain, S. N. and Johnson, D. V. 2018. *Advances in Plant Breeding Strategies*.

Vol. 3: Fruits. Springer

Badenes, S. and Byrne, D.H. 2012. *Fruit Breeding*. Springer.

Hancock, J. F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer
Kole, C. and Abbott, A. G. 2012. *Genetics, Genomics and Breeding of Stone fruits*. CRC
Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resources: Tropical and*

Subtropical Fruits. Springer-Verlag

Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits*.

Springer -Verlag.

Jain, S. N. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: Tropical Species; Temperate Species*. Springer -Verlag.

Janick, J. and Moore, J.N., 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons, USA.
Orton, T. 2019. *Methods in Fruit Breeding*. Elsevier.

Singh, S.K., Patel, V.B., Goswami, A.K., Jai Prakash and Chavlesh Kumar.2019. *Breeding of Perennial Horticultural Crops*. Biotech Books. Delhi

FSC-612 MODERN TRENDS IN FRUIT PRODUCTION (3+0)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Current Scenario: National and International scenario, national problems.

Block 2: Advanced Technologies

UNIT I: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation

- root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation.

Block 3: Management Practices

UNIT I: Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM) - Current topics.

CROPS:

Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry, Almond, Walnut, Pecan, Strawberry, Kiwifruit

RESOURCES

Bartholomew, D.P., Paull, R.E. and Rohrbach, K.G. eds., 2002. *The Pineapple: Botany, Production, and Uses*. CAB International.

Bose, T.K., Mitra, S.K. and Sanyal, D., Eds., 2002. *Fruits of India – Tropical and Sub-Tropical*. 3rd Ed. Vols. I, II. Naya Udyog, Kolkata, India.

Dhillon, W.S. and Bhatt, Z. A., 2011. *Fruit Tree Physiology*. Narendra Publishing House, New Delhi.

Dhillon, W.S., 2013. *Fruit Production in India*. Narendra Publishing House, New Delhi. Gowen, S., 1995. *Bananas and Plantains*. Chapman & Hall Publication, US.

Litz, R.E. ed., 2009. *The Mango: Botany, Production and Uses*. CAB International. Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi.

Robinson, J.C. and Saúco, V.G., 2010. *Bananas and Plantains* (Vol. 19). CAB International. Samson, J.A., 1980. *Tropical Fruits*. Longman, USA.

Sharma, R.R. and Krishna, H. 2014. *Fruit Production: Major Fruits*. Daya Publishing House, Delhi.

Singh, S., Shivankar, V.J., Srivastava, A.K. and Singh, I.P. 2004. *Advances in Citriculture*.

Jagminder Book Agency, New Delhi.

Stover, R.H. and Simmonds, N.W. 1991. *Bananas*. Longman, USA

Chadha, K.L., Ahmed, N., Singh, S.K., Kalia P. 2016. *Temperate Fruits and Nuts- Way Forward for Enhancing Production and Quality*. Daya Publishing House, New Delhi Childers, N. F., Morris, J. R. and Sibbett, G. S. 1995. *Modern Fruit Science: Orchard and*

Small Fruit Culture. Horticultural Publications, USA.

Erez, A. 2013. *Temperate Fruit Crops in Warm Climates*. Springer Science. Jackson, D., Thiele, G., Looney, N. E. and Morley-Bunker, M. 2011. *Temperate and*

Subtropical Fruit Production. CAB International

Ryugo, K. 1998. *Fruit Culture: Its Science and Art*. John Wiley & Sons, USA.

Tromp, J., Webster, A. S. and Wertheim, S. J. 2005. *Fundamentals of Temperate Zone Tree Fruit Production*. Backhuys Publishers, Lieden, The Netherlands.

Westwood, M. N. 2009. *Temperate Zone Pomology : Physiology and Culture*. 3rd Edn.

Timber Press, USA.

FSC-613 RECENT DEVELOPMENTS IN GROWTH REGULATION (3+0)

THEORY

Block 1: Introduction

UNIT I: Current Concepts and Principles: Eco-physiological influences on growth and development of fruit crops-flowering, fruit set- Crop load and assimilate partitioning and distribution.

Block 2: Growth Substances

UNIT I: Phytohormones 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. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal

synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

Block 3: Growth and Development

UNIT I: Regulation of Developmental Processes: Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production.

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

RESOURCES

Bhatnagar, P. 2017. *Physiology of Growth and Development of Horticultural Crops*.

Agrobios (India).

Buchanan, B., Gruissam, W. and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley & Sons, US.

Fosket, D.E. 1994. *Plant Growth and Development : A Molecular Approach*. Academic Press, USA.

Leopold, A.C and Kriedermann, P.E., 1985. *Plant Growth and Development*. 3rd Ed.

McGraw-Hill, US.

Richard N. Artica, 1995. *Plant Growth Substances – Principles and Applications*. Chapman & Hall, USA.

Roberts, J., Downs, S. and Parker, P., 2002. *Plant Growth Development*. In: *Plants* (I. Ridge, Ed.), Oxford University Press.

Salisbury, F.B. and Ross, C.W., 1992. *Plant Physiology*. 4th Ed. Wadsworth Publication.

FSC-614 ADVANCED LABORATORY TECHNIQUES (1+2)

THEORY

Block 1: General Aspects

UNIT 1: Safety Measures and Laboratory Maintenance: Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

Block 2: Qualitative and Quantitative Analysis

UNIT I: Destructive and Non-destructive Analysis Methods: Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

UNIT II: Chromatographic and Microscopic Analysis: Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.

UNIT III: 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.

PRACTICALS

- Determination of moisture, relative water content and physiological loss in weight(2)
- Determination of biochemical components in horticultural produce(3)
- Calibration and standardization of instruments(1)
- Textural properties of harvested produce(1)
- Determination of starch index (SI) (1)
- Specific gravity for determination of maturity assessment, and pH of produce(1)
- Detection of adulterations in fresh as well as processed products(2)
- Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch(2)
- Estimation of rate of ethylene evolution using gas chromatograph (GC) (2)
- Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.) (2)

RESOURCES

AOAC International. 2003. *Official Methods of Analysis of AOAC International*. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities, USA.

Clifton, M. and Pomeroy, Y. 1988. *Food Analysis-Laboratory Experiments*. AVI Publication, USA.

Linskens, H. F. And Jackson, J. F. 1995. *Fruit Analysis*. Springer.

Leo, M.L. 2004. *Handbook of Food Analysis*. 2nd Ed. Vols. I-III, USA.

Pomeroy, Y. and Meloan, C.E. 1996. *Food Analysis - Theory & Practice*. CBS, USA. Ranganna, S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable*

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

Thompson, A.K. 1995. *Post Harvest Technology of Fruits and Vegetables*. Blackwell Sciences.

FSC-621 ARID AND DRYLAND FRUIT PRODUCTION (2+0)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Current Scenario: Characteristics features and major constraints of the arid and dryland region, distinguishing features of the fruit species trees for adaptation in adapting to the region, nutritional and pharmaceutical importance, national problems.

Block 2: Advanced Technologies

UNIT I: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation

- root stocks, planting systems, High density planting, crop modelling, Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation, effects on physiology and development, influence of stress factors.

Block 3: Management Practices

UNIT I: Stress Mitigation and Integrated Approaches: Strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, total quality management(TQM) - Current topics.

CROPS:

Aonla, Annonas, ber, bael, jamun, date palm, cactus pear, khejri, kair, pilu, lasoda, manila, tamarind, monkey jack, mahua, khirni, amra, seabuckthorn, chilgoza, cafel, rhododendron, box myrtle, chironji, phalsa, karonda, woodapple, paniala and other minor fruits of regional importance

RESOURCES

Krishna, H. and Sharma, R.R. 2017. *Fruit Production - Minor Fruits*. Daya Publishing House, Delhi.

Hiwale, S. 2015. *Sustainable Horticulture in Semiarid Drylands*. Springer.

More, T. A. Singh, R. S. Bhargava, R. and Sharma, B. D. 2012. *Arid Horticulture for Nutrition and Livelihood*. Agrotech Publishing Academy, Udaipur (Rajasthan).

Pareek, O. P., Sharma, S. and Arora, R. K. 2007. *Underutilised Edible Fruits and Nuts*,

IPGRI, Rome.

Peter, K.V. 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, N. Delhi. Saroj, P. L., Dhandar, D. G. and Vashishta, B. B. 2004. *Advances in Arid Horticulture*, Vol.-1

Present Status. IBDC, Lucknow.

Saroj, P. L. and Awasthi, O. P. 2005. *Advances in Arid Horticulture*, Vol: II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.

Sontakke, M. B. 2014. *Production and Management of Fruit crops in Arid/ Drylands*. Agrotech Publishing Academy, Udaipur (Rajasthan).

FSC-622 ABIOTIC STRESS MANAGEMENT IN FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

UNIT I: Basic Aspects and Principles: 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.). Pollution - increased level of CO₂, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.

Block 2: Stress Impact

UNIT I: 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.

Block 3: Stress Management

UNIT I: Mitigation Measures and Conservation Practices: Greenhouse 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, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.

PRACTICALS

2. Seed treatment /hardening practices (2)
3. Container seedling production(2)
4. Analysis of soil moisture estimates (FC, ASM, PWP) (1)
5. Analysis of plant stress factors, RWC, chlorophyll fluorescence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations(5)
6. Biological efficiencies, WUE, solar energy conversion and efficiency(2)
7. Crop growth sustainability indices and economics of stress management(2)
8. Visit to orchards and watershed locations(2)

RESOURCES

Blumm, A. 1988. *Plant Breeding for Stress Environments*. CRC Publication, USA. Christiansen, M.N. and Lewis, C.F. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International Science, USA.

Kanayama, Y. And Kochetor. 2015. *Abiotic Stress Biology in Horticultural Plants*. Springer. Kramer, P.J., 1980. *Drought Stress and the Origin of Adaptation*. In: *Adaptation of Plants to*

Water and High Temperature Stress. John Wiley & Sons, USA.

Maloo, S.R. 2003. *Abiotic Stress and Crop Productivity*. AgrotechPubl.Academy, India. Nickell, L.G. 1983. *Plant Growth Regulating Chemicals*. CRC Publication, USA.

Rao. N.K.S., Shivashankar, K.S. and Laxman, R.H. 2016. *Abiotic Stress Physiology of Horticultural Crops*. Springer.

Turner, N.C. and Kramer, P.J. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons, USA.

FSC-623 BIODIVERSITY AND CONSERVATION OF FRUIT CROPS (2+1)

THEORY

Block 1: GENERAL ASPECTS

UNIT I: Issues, Goals and Current Status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/database of fruit crops in India

Block 2: Germplasm Conservation

UNIT I: Collection, Maintenance and Characterization: Exploration and collection of germplasm; sampling frequencies ; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- *in situ* and *ex situ* strategies, on farm conservation; problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

Block 3: Regulatory Horticulture

UNIT I: Germplasm Exchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phyto- sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV&FR Act.

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.

PRACTICALS

1. Documentation of germplasm- maintenance of passport data and other records of accessions (2)
2. Field exploration trips and sampling procedures(2)
3. Exercise on *ex situ* conservation – cold storage, pollen/seed storage(2)
4. Cryopreservation(2)
5. Visits to National Gene Bank and other centers of PGR activities(2)
6. Detection of genetic constitution of germplasm(2)
7. Germplasm characterization using a standardised DUS test protocol(2)
8. Special tests with biochemical and molecular markers(2)

RESOURCES

Dhillon, B. S., Tyagi, R. K., Lal, A. and Saxena, S. 2004. *Plant Genetic Resource Management. – Horticultural Crops*. Narosa Publishing House, New Delhi.

Engles, J. M., Ramanath R, V., Brown, A. H. D. and Jackson, M. T. 2002. *Managing Plant Genetic Resources*, CABI, Wallingford, UK.

Frankel, O.H. and Hawkes, J.G., 1975. *Crop Genetic Resources for Today and Tomorrow*.

Cambridge University Press, USA.

Hancock, J. 2012. *Plant Evolution and the Origin of Crops Species*. CAB International. Jackson, M., Ford-Lloyd, B. and Parry, M. 2014. *Plant Genetic Resources and Climate*

Change. CABI, Wallingford, UK

Moore, J. N. and Ballington Jr, J. R. 1991. *Genetic Resources of Temperate Fruit and Nut Crops*. ISHS, Belgium.

Peter, K.V.2008. *Biodiversity of Horticultural Crops*. Vol. II. Daya Publ. House, Delhi.

Peter,K.V.2011. *Biodiversity in HorticulturalCrops*.Vol.III. Daya Publ. House, Delhi.

Rana, J. C. and Verma, V. D. 2011. *Genetic Resources of Temperate Minor Fruits (Indigenous and Exotic)*. NBPGR, New Delhi.

Rajasekharan, P. E., Rao, V and Ramanatha, V. 2019. *Conservation and Utilization of Horticultural Genetic Resources*. Springer.

Sthapit, B., et al. 2016. *Tropical Fruit Tree Diversity (Good Practices for in situ and ex situ conservation)*. Bioversity International. Routledge, Taylor and Francis Group.

Virchow, D., 2012. *Conservation of Genetic Resources*, Springer Verlag, Berlin

FSC-624 SMART FRUIT PRODUCTION (2+0)

THEORY

Block 1: Introduction

UNIT I: Importance and Overview: Introduction and importance; concepts and applications of artificial intelligence systems; case studies in horticulture

Block 2: Crop Modelling and Forecasting

UNIT I: GIS, Sensors and Wireless Systems: 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,

Block 3: Nanotechnology

UNIT I: Concepts and Methods: Nanotechnology for smart nutrient delivery in fruit farming, concepts and methods, practical utility, nano-fertilizers, nano-herbicides; nano-pesticides

Block 4: Innovative Approaches

UNIT I: Mechanization, Automation and Robotics: Production systems amenable to automation and mechanization; automated protected structures (turn-key systems); hydroponics, aeroponics, bioreactors for large scale plant multiplication; Use of drones and robotics in fruit growing – robotic planters, sprayers, shakers, harvesters, stackers etc. Visit to Hi-tech facilities.

RESOURCES

Chadha *et al.* 2017. *Doubling Farmers Incomes through Horticulture*. Daya Publishing House, New Delhi.

Chadha *et al.* 2019.*Shaping the Future of Horticulture*. Kruger Brentt Publishers, UK.

Hewett, E. W. 2013. *Automation, Mechanization and Robotics in Horticulture*. In: Workshop on Emerging Postharvest Technologies. UC, Davis, USA.

<http://horticulture.ucdavis.edu>- Innovative Technology for Horticultural Department. Prasad, S., Singh, D. and Bhardwaj, R. L. 2012. *Hi-Tech Horticulture*. Agrobios (India).

Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi. Tyagi, S. 2019. *Hi- Tech Horticulture*. Vols. 1 to 7. NIPA, New Delhi.

Zhang, Q. 2017. *Automation in Tree Fruit production – Principles and Practice*. CABI.

(ii) Ph. D. (Hort.) Vegetable Science

Major Courses

Course code	Course Title	Credit hrs.
	Semester-I	
VSC 611*	Recent Trends in Vegetable Production	3+0
VSC 612*	Advances in Breeding of Vegetable Crops	3+0
VSC 613	Abiotic Stress Management in Vegetable Crops	2+1
VSC 614	Seed Certification, Processing and Storage of Vegetable Crops	2+1
	Semester-II	
VSC 621	Breeding of Special Traits in Vegetable Crops	2+0
VSC 622	Biodiversity and Conservation of Vegetable Crops	2+1
VSC 623	Biotechnological Approaches in Vegetable Crops	2+1
VSC 624	Advanced Laboratory Techniques for Vegetable Crops	1+2
	Semester-III	
VSC 691	Seminar-I	1+0
	Semester-IV	
VSC 692	Seminar-II	1+0
VSC-690	Comprehensive	NC
	Semester-V & VI	
VSC 699	Research	0+75

*Core and Compulsory courses

Syllabus of Major courses of Ph.D. (Hort.) Vegetable Science

VSC-611 RECENT TRENDS IN VEGETABLE PRODUCTION (3+0)

THEORY

Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost polyhouse; nethouse production; crop modelling, organic gardening; vegetable production for pigments, export and processing of:

UNIT-I: *Solanaceous crops*: Tomato, brinjal, chilli, sweet pepper and potato. UNIT-II: *Cole crops*: Cabbage, cauliflower and knol-khol, sprouting broccoli. UNIT-III: Okra, onion, peas and beans, amaranth and drumstick.

UNIT-IV: *Root crops and cucurbits*: Carrot, beet root, turnip and radish and cucurbits UNIT-V: *Tuber crops*: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

RESOURCES

Bose, T.K. and Som, N.G., 1986, Vegetable crops of India. Naya prokash.

Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003, Vegetable crops. Vols. I-III. Naya Udyog.

Brewster, J.L., 1994, Onions and other vegetable alliums. CABI.

- Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances in horticulture Vols. V-X. Malhotra Publ. House.
- Chadha, K.L. (Ed.), 2002, Hand book of horticulture. ICAR.
- Chauhan, D.V.S. (Ed.), 1986, Vegetable production in India. Ram prasad and Sons.
- Fageria, M.S., Choudhary, B.R. and Dhaka, R.S., 2000, Vegetable crops: production technology. Vol. II. Kalyani. FFTC., Improved vegetable production in Asia. Book Series No. 36.
- Ghosh, S.P., Ramanujam, T., Jos, J.S., Moorthy, S.N. and Nair, R.G., 1988, Tuber crops. Oxford and IBH.
- Gopalakrishanan, T.R., 2007, Vegetable crops. New India Publ. Agency.
- Hazra, P. and Som, M.G., 2015, Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.
- Hazra, P., 2016, Vegetable science. 2nd edn, Kalyani publishers, Ludhiana.
- Hazra, P., 2019, Vegetable production and technology. New India publishing agency, New Delhi.
- Kallo, G. and Singh, K. (Ed.), 2001, Emerging scenario in vegetable research and development. Research periodicals and Book Publ. House.
- Kurup, G.T., Palanisami, M.S., Potty, V.P., Padmaja, G., Kabeerathuma, S. and Pallai, S.V., 1996, Tropical tuber crops, problems, prospects and future strategies. Oxford and IBH.
- Rana, M.K., 2008, Olericulture in India. Kalyani Publ.
- Rana, M.K., 2008, Scientific cultivation of vegetables. Kalyani Publ.
- Rubatzky, V.E. and Yamaguchi, M. (Eds.), 1997, World vegetables: principles, production and nutritive values. Chapman and Hall.
- Saini, G.S., 2001, A Text Book of oleri and flori culture. Aman Publishing House.
- Salunkhe, D.K. and Kadam, S.S. (Ed.), 1998, Hand book of vegetable science and technology: production, composition, storage and processing. Marcel Dekker.
- Shanmugavelu, K.G., 1989, Production technology of vegetable crops. Oxford and IBH. Sin, M.T. and Onwueme, I.C., 1978, The tropical tuber crops. John Wiley and Sons.
- Singh, D.K., 2007, Modern vegetable varieties and production technology. International book distributing Co.
- Singh, N.P., Bhardwaj, A.K., Kumar, A. and Singh, K.M., 2004, Modern technology on Vegetable production. International book distr. Co.
- Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2006, Hybrid vegetable development.
International book distr. Co.
- Singh, S.P. (Ed.), 1989, Production technology of vegetable crops. Agril. Comm. Res. Centre.
- Thamburaj, S. and Singh, N. (Eds.). 2004, Vegetables, tuber crops and spices. ICAR. Thompson, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.

VSC-612 ADVANCES IN BREEDING OF VEGETABLE CROPS (3 +0)

THEORY

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

UNIT-I: *Solanaceous crops* - Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato UNIT-II: Cucurbits and Cole crops

UNIT-III: *Legumes and leafy vegetables* - Peas and Beans, Amaranth, Palak, Chenopods andLettuce.

UNIT-IV: *Root crops and onion* - Carrot, Beetroot, Radish, Turnip, Onion

UNIT-V: *Tuber crops* - Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea

RESOURCES

Allard, R.W., 1999, Principle of plant breeding. John Willey and Sons, USA. Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.

Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: Breeding and seed production. Vol. I. Kalyani.

Gardner, E.J., 1975, Principles of genetics. John Wiley and Sons.

Hayes, H.K., Immer, F.R. and Smith, D.C., 1955, Methods of plant breeding. McGraw-Hill.

Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.), 1993, Plant Breeding-principles and prospects. Chapman and Hall.

Hazra, P. and Som, M.G., 2015, Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p

Hazra, P. and Som, M.G., 2016, Vegetable seed production and hybrid technology(Second revised edition), Kalyani Publishers, Ludhiana, 459 p

Kaloo, G., 1988, Vegetable breeding (Vol. I, II, III). CRC Press, FI, USA. Kaloo, G., 1988, Vegetable breeding. Vols. I-III. CRC Press.

Kaloo, G., 1998, Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. BookAgency.

Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops.

Agro Botanical Publ.

Paroda, R.S. and Kaloo, G. (Eds.), 1995, Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.

Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables. Revised, ICAR.

- Peter, K.V. and Hazra, P. (Eds), 2012, Hand book of vegetables. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
- Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency. Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ.
- Simmonds, N.W., 1978, Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publ.
- Singh, B.D., 1983, Plant breeding. Kalyani Publ.
- Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International Book Distributing Co.
- Swarup, V., 1976, Breeding procedure for cross-pollinated vegetable crops. ICAR.

VSC-613 ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS (2+1)

THEORY

Block 1: Abiotic stress management in vegetable crops

UNIT I: *Environmental stress* - its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

UNIT II: *Mechanism and measurements* - tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT III: *Soil-plant-water relations* - under different stress conditions in vegetable crops production and their management practices.

UNIT IV: Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT V: Use of chemicals - techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.

PRACTICAL

- (i) Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops
- (ii) measurement of tolerance to various stresses in vegetable crops,
- (iii) short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions,
- (iv) Use of chemicals for alleviation of different stresses.

RESOURCES

- Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.
- Dwivedi, P. and Dwivedi, R.S., 2005, Physiology of abiotic stress in plants. Agrobios. Janick, J.J., 1986, Horticultural science. 4th Ed. WH Freeman and Co.
- Kaloo, G. and Singh, K., 2001, Emerging scenario in vegetable research and development. Research periodicals and book publ. house.
- Kaloo, G., 1994, Vegetable breeding. Vols. I-III. Vedams eBooks.
- Lerner, H.R. (Eds.), 1999, Plant responses to environmental stresses. Marcel Decker. Maloo, S.R., 2003, Abiotic stresses and crop productivity. Agrotech Publ. Academy. Narendra, T. *et al.*, 2012, Improving crops resistance to abiotic stress. Wiley and Sons.US.
- Peter, K.V. and Pradeep Kumar, T., 2008, Genetics and breeding of vegetables. (Revised Ed.). ICAR.
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
- Ram, H.H., 2001, Vegetable breeding. Kalyani.
- Rao, N.K. (Eds.), 2016, Abiotic stress physiology of horticultural crops. Springer publication.

VSC-614 SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE SEEDS (2+1)

THEORY

Block 1: Seed Certification, Processing and Storage of Vegetable Seeds.

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

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

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

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

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

PRACTICAL

- General procedures of seed certification

- Field inspection and standards
- Isolation and rouging
- Inspection and sampling at harvesting, threshing and processing
- Testing physical purity, germination and moisture, grow-out test
- Visit to regulatory seed testing and plant quarantine laboratories
- Seed processing plants and commercial seed stores

RESOURCES

Agarwaal, P. K. and Anuradha, V., 2018, Fundamentals of seed science and technology.

Brilliant publications, New Delhi.

Basra, A. S., 2000, Hybrid seed production in vegetables. CRC press, Florida, USA.

Bench, A.L.R. and Sanchez, R.A., 2004, Handbook of seed physiology. Food products press, NY/ London.

Chakraborty, S. K., Prakash, S., Sharma, S.P. and Dadlani, M., 2002, Testing of distinctiveness, uniformity and stability for plant variety protection. IARI, New Delhi

Copland, L.O. and McDonald, M.B., 2004, Seed science and technology, Kluwer academic press.

Fageria, M.S., Arya, P.S. and Choudhry, A.K., 2000, Vegetable crops: breeding and seed production Vol 1. Kalyani publishers, New Delhi.

George, R.A.T., 1999, Vegetable seed production (2nd Edition). CAB International.

Hazra, P. and Som, M.G., 2016, Vegetable seed production and hybrid technology (Second revised edition), Kalyani publishers, Ludhiana, 459 p

Kaloo, G., Jain, S.K., Vari, A.K. and Srivastava, U., 2006, Seed: A global perspective.

Associated publishing company, New Delhi.

Singhal, N.C., 2003, Hybrid seed production. Kalyani publishers, New Delhi.

VSC-621- BREEDING FOR SPECIAL TRAITS IN VEGETABLE CROPS (2+0)

THEORY

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

UNIT I: Brassica group, carrot and beetroot UNIT II: Tomato, brinjal, peppers and potato

UNIT III: Green leafy vegetables, Legume crops and okra UNIT IV: Cucurbitaceous vegetable crops and edible Alliums

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

RESOURCES

- Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons. Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.
- Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.
- Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: Breeding and seed production. Vol. I. Kalyani.
- Gardner, E.J., 1975, Principles of genetics. John Wiley and Sons.
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- Hazra, P. and Som, M.G., 2015, Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p
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- Kaloo, G., 1988, Vegetable breeding. Vols. I-III. CRC Press.
- Kaloo, G., 1998, Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. BookAgency.
- Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro Botanical Publ.
- Paroda, R.S. and Kaloo, G. (Eds.), 1995, Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.
- Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables. Revised, ICAR.
- Peter, K.V. and Hazra, P. (Eds), 2012, Hand book of vegetables. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
- Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
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- Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency. Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ.
- Rout, G.R. and Peter, K.V., 2008, Genetic engineering of horticultural crops. Academicpress, Elsevier, USA
- Simmonds, N.W., 1978, Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publ.
- Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International Book Distributing Co.
- Swarup, V., 1976, Breeding procedure for cross-pollinated vegetable crops. ICAR.

VSC-622 BIODIVERSITY AND CONSERVATION OF VEGETABLE CROPS (2+1)

THEORY

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

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

UNIT III: *Regulatory horticulture* :Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. 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.

PRACTICALS

- Documentation of germplasm- maintenance of passport data and other records of accessions
- Field exploration trips and sampling procedures
- Exercise on *ex situ* conservation – cold storage, pollen/seed storage
- Cryopreservation
- Visits to national gene bank and other centers of PGR activities
- Detection of genetic constitution of germplasm
- Germplasm characterization using a standardised DUS test protocol
- Special tests with biochemical and molecular markers

RESOURCES

- Dhillon, B. S., Tyagi, R. K., Lal, A. and Saxena, S., 2004, Plant genetic resource management. – horticultural crops. Narosa publishing house, New Delhi.
- Engles, J. M., Ramanath R, V., Brown, A. H. D. and Jackson, M. T., 2002, Managing plant genetic resources, CABI, Wallingford, UK.
- Frankel, O.H. and Hawkes, J.G., 1975, Crop genetic resources for today and tomorrow. Cambridge University Press, USA.
- Hancock, J., 2012, Plant evolution and the origin of crops species. CAB International.
- Jackson, M., Ford-Lloyd, B. and Parry, M., 2014, Plant genetic resources and climate change. CABI, Wallingford, UK
- Moore, J.N. and Ballington, J.R. 1991, Genetic resources of temperate Fruit and nut crops. ISHS, Belgium.
- Peter, K.V., 2008, Biodiversity of horticultural crops. Vol. II. Daya Publ. House, Delhi. Peter, K.V., 2011, Biodiversity in horticultural crops. Vol.III. Daya publ. house, Delhi.

- Rajasekharan, P.E., Rao, V. and Ramanatha, V., 2019, Conservation and utilization of horticultural genetic resources. Springer.
- Rana, J.C. and Verma, V.D., 2011, Genetic resources of temperate minor fruits (indigenous and exotic). NBPGR, New Delhi.
- Sthapit, *et al.*, 2016, Tropical fruit tree diversity (good practices for in situ and ex situ conservation). Bioversity international. routledge, Taylor and Francis Group.
- Virchow, D., 2012, Conservation of genetic resources, Springer Verlag, Berlin

VSC-623 BIOTECHNOLOGICAL APPROACHES IN VEGETABLE CROPS (2+1)

THEORY

Block 1: Biotechnological approaches in vegetable crops

UNIT I: *Importance and scope of biotechnology* - in vegetable crop improvement. *In vitro* culture, micropropagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.

UNIT II: *Somatic embryogenesis* - somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.

UNIT III: *Blotting techniques, DNA finger printing* - Molecular markers/DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes. QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco-TILLING. UNIT IV: *Plant genetic engineering* - Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Bio-safety issue, regulatory issues for commercial approval.

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

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

PRACTICALS

1. Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production (2)
2. *In vitro* mutation induction, *in vitro* rooting – hardening at primary and secondary nurseries (3).
3. DNA isolation from economic vegetable crop varieties – Quantification and amplification (2) DNA and Protein profiling – molecular markers, PCR Handling (2)
4. Vectors for cloning and particle bombardment (3)
5. DNA fingerprinting of flower crop varieties (3)
6. Project preparation for establishment of low, medium and high cost tissue culture laboratories (1)

RESOURCES

Bajaj, Y.P.S. (Ed.), 1987, Biotechnology in agriculture and forestry. Vol. XIX. Hitech and Micropropagation. Springer.

- Chadha, K.L., Ravindran, P.N. and Sahijram, L. (Eds.), 2000, Biotechnology of horticulture and plantation crops. Malhotra Publ. House.
- Debnath, M., 2005, Tools and techniques of biotechnology. Pointer publication, New Delhi. Glover, M.D., 1984, Gene cloning: the mechanics of DNA manipulation. Chapman and Hall. Gordon, H. and Rubsell, S., 1960, Hormones and cell culture. AB Book Publ.
- Keshavachandran, R., 2007, Recent trends in biotechnology of horticultural crops. New IndiaPubl. Agency.
- Keshavachandran, R. and Peter, K.V., 2008, Plant biotechnology; tissue culture and gene transfer. Orient and Longman, USA.
- Keshavachandran, R., 2007, Recent trends in biotechnology of horticultural crops. New - India publication agency, New Delhi.
- Panopoulos, N.J. (Ed.), 1981, Genetic engineering in plant sciences. Praeger Publ. Parthasarathy, V.A., Bose, T.K., Deka, P.C., Das, P., Mitra, S.K. and Mohanadas, S., 2001, Biotechnology of horticultural crops. Vols. I-III. Naya Prokash.
- Pierik, R.L.M., 1987, In vitro culture of higher plants. MartinusNijhoff Publ.
- Prasad, S., 1999, Impact of plant biotechnology on horticulture. 2nd Ed. Agro Botanica.
- Rout, G.R. and Peter, K.V., 2018, Genetic engineering of horticultural crops. Academic press Elsevier, USA.
- Sharma, R., 2000, Plant tissue culture. Campus Books.
- Singh, B.D., 2010, Biotechnology- expanding horizons. Kalyani Publishers, New Delhi.
- Skoog, Y. and Miller, C.O., 1957, Chemical regulation of growth and formation in plant tissue cultured in vitro. Attidel. II Symp. On biotechnology action of growth substance.
- Vasil, T.K., Vasi, M., While, D.N.R. and Bery, H.R., 1979, Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture. Planum Press.

VSC- 624 ADVANCED LABORATORY TECHNIQUES FOR VEGETABLE CROPS(1+2)

THEORY

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

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

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

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

PRACTICALS

- Determination of moisture, relative water content and physiological loss in weight
- Determination of biochemical components in horticultural produce
- Calibration and standardization of instruments
- Textural properties of harvested produce
- Determination of starch index (SI)
- Specific gravity for determination of maturity assessment, and pH of produce
- Detection of adulterations in fresh as well as processed products
- Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch
- Estimation of rate of ethylene evolution using gas chromatograph (GC)
- Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.)

RESOURCES

AOAC International, 2003, Official methods of analysis of AOAC international. 17th Ed.

Gaithersburg, MD, USA, association of analytical communities, USA.

Clifton, M. and Pomeranz, Y., 1988, Food analysis - laboratory experiments. AVI publication, USA.

Linskens, H.F. And Jackson, J.F., 1995, Fruit analysis. Springer.

Leo, M.L., 2004, Handbook of food analysis, 2nd Ed. Vols. I-III, USA.

Pomrenz, Y. and Meloan, C.E., 1996, Food analysis - theory and practice. CBS, USA.

Ranganna, S. 2001. Handbook of analysis and quality control for fruit and vegetable products. 2nd Ed. Tata-McGraw-Hill, New Delhi.

Thompson, A.K., 1995, Postharvest technology of fruits and vegetables. Blackwell sciences. USA.

(iii) Ph.D. (Forestry) Silviculture & Agroforestry

Major courses

Course code	Course Title	Credit hrs.
	Semester-I	
SAF-611	Quantitative Silviculture	2+1
SAF-612	Forest Stand Dynamics	1+0
SAF-613	Forest Stand Management Techniques	1+1
SAF-614	Plantation Forest Productivity	1+1
SAF-615	Regeneration Silviculture	2+1
SAF-616	Agroforestry for Sustainable Agriculture	1+0
	Semester-II	
SAF-621	Agroforestry Research and Management	2+0
SAF-622	Productivity and Evaluation of Agroforestry Systems	2+1
SAF-623	Agroforestry for Ecosystem Services and Environmental Benefits	2+0
SAF-624	Restoration Forestry	1+0
SAF-625	Forest Soil Management	1+1
	Semester-III	
SAF-691	Doctoral Seminar I	1+0
	Semester-IV	
SAF-692	Doctoral Seminar II	1+0
	Semester-V & VI	
SAF-699	Doctoral Research	0+75

*Core and compulsory courses

Syllabus of Major courses of Ph.D. (Forestry) Silviculture and Agroforestry

SAF 611 QUANTITATIVE SILVICULTURE 2+1

Theory

UNIT I

Principles of tree and stand growth and yield. Habitat types; site quality; site index.

Growth functions - empirical, exponential, allometry and Backman's growth functions. Growth pattern and growth increment curve. Growth cycle and phases.

Quantifying site quality: Methods - tree and stand height data, periodic height growth. Techniques - guide curves, difference equations, parameter prediction.

UNIT II

Stand density and stocking, measures of density: $-3/2$ power rule of self-thinning, point density, competition indices. Control of growing stock to achieve specific management objectives - growth-growing stock relations, Full site occupancy, Onset of competitive interactions. Langsaeter's hypothesis, stand density index and techniques for translating this understanding into rational density management regimes.

UNIT III

Techniques: stand density management diagrams and stocking charts. Construction and use of stand density management diagrams. Designing density management regimes to suit specific management objectives.

UNIT IV

Predicting growth and yield: normal and empirical yield tables, stand growth and yield equations, stand table projections. Simulation models: whole-stand models, size-class distribution models, single-tree/ distance-independent and distance-dependent models, process models, linkage of models at different levels. Evaluation, calibration, verification, and validation of forest growth and yield prediction systems. Introduction to existing forest growth and yield simulators.

Practical

Assessment of growth characteristics. Preparation of growth and increment curves. Site quality assessment, Stand density diagrams. Growth prediction models. Yield simulation techniques.

Suggested Readings

Clutter JL, Fortson JC, Pienaar LV, Brister GH and Bailey RL. 1992. *Timber Management: A Quantitative Approach*. Krieger Publishing Company.

Davis LS and Johnson KN. 1987. *Forest Management*. 3rd Ed. McGraw-Hill.

Evans J. 1982. *Plantation Forestry in the Tropics*. Clarendon Press.

Johnson PS, Shifley SR and R. Rogers. 2009. *Self-thinning and Stand Density. The Ecology and Silviculture of Oaks*. CABI, Cambridge, MA.

Luna RK. 1989. *Plantation Forestry in India*. International Book distributors.

Vanclay JK. 1994. *Modeling Forest Growth and Yield: Application to Mixed Tropical Forests*. CAB International.

SAF 612

FOREST STAND DYNAMICS

1+0

Theory

UNIT I

Introduction-plant interactions and limitations of growth - mutualism and competition – the niche - limitations of growth - concept of growing space.

UNIT II

Tree architecture and growth- general growth patterns - shoot development patterns, crown shapes, height growth, root growth, and tree development.

UNIT III

Disturbances and stand development – impact of disturbances - major and minor- classification of disturbances - characteristics of disturbance agents. Stand structure and fire behaviour. Building resilience to disturbances.

UNIT IV

Overview of stand development patterns - temporal and spatial patterns of tree invasion - stand initiation stage - stem exclusion stage – understory reinitiation stage - old growth stage - multicohort stands – behaviour of component cohorts- development of multicohort stands - quantification of stand development - forest patterns over long times and large areas. Gap dynamics.

Suggested Readings

- Dagar JC, Tewari JC, Vindhya Prasad. 2018. *Agroforestry Anecdotal to Modern Science*. Springer.
- Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*, 2nd edition, McGraw-Hill, 2nd ed.
- Kimmins JP. 1997. *Forest Ecology*, Macmillan Publishing Company, New York Upper Saddle River, Prentice Hall.
- Koop H. 1989. *Forest Dynamics Silvi-star: A Comprehensive Monitoring System*. Springer-verlag. New York.
- Oliver CD and Larson BC. 1996. *Forest Stand Dynamics*. John Wiley & Sons, Inc. New York New York: John Wiley & Sons, Inc.
- Smith DM. 1986. *The Practice of Silviculture*, 8th ed, Wiley, New York.
- Waring RH and Schlesinger WH. 1985. *Forest ecosystems: Concepts and management*, Academic. Press, San Diego.

SAF 613

FOREST STAND MANAGEMENT TECHNIQUES

1+1

Theory

UNIT I

Philosophy of silviculture – advance reproduction methods and their role in silviculture – Judging successful establishment; Analysis of active and passive site preparation – Silviculture with an ecosystem approach.

UNIT II

Advances in silvicultural practices; tropical forest, sub-tropical forest and temperate forest.

UNIT III

Analysis of different techniques of silviculture in forest stand management, Technique for early stand development; Analysis of thinning methods and its impact on wood yield and quality; Stand protection and health management. Silvicultural use of prescribed fire. Mechanization and role in silviculture.

UNIT IV

Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad; mixed plantation forestry, Precision silviculture, silviculture of intensively managed plantations, silviculture for climate change mitigation. Sewage silviculture. Silviculture management for watershed and catchment areas. Silviculture for wildlife habitat improvement.

UNIT V

Adjusting silviculture to meet industrial demands – silviculture in perspective – Problem solving procedure for silviculture – silviculture in retrospect.

Practical

Study of components of silvicultural system for sustained yield; Management strategies for even aged and uneven aged stands; Choice of site preparation methods, Plantation map, Quality planting stock, Planning for tree planting, Release cutting operation, Selection of thinning methods, Intensity of thinning, Analysis of site quality and biomass production for timber, pulp wood and fuel wood species, Problems in silviculture in tropical, subtropical plantation and their solutions.

Suggested Readings

- Brang P, Spathelf P, Larsen JB, Bauhus J, Bončina A and Chauvin C. 2014. *Suitability of Close-To-Nature Silviculture for Adapting Temperate European Forests to Climate Change*. Forestry.
- Colak AH, Rotherham ID and Calikoglu M. 2003. *Combining 'Naturalness Concepts' with Close-to-Nature Silviculture*. Forstwiss. Centralbl. 122, 421–431.
- Cole DN and Yung L. (eds) 2010. *Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change*. Island Press.
- Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture*, 2nd edition, McGraw-Hill, 2nd ed.
- Fettig CJ, Reid ML, Bentz BJ, Sevanto S, Spittlehouse DL and Wang T. 2013. *Changing climates, changing forests: A western North American perspective*.
- Franklin JF. 1989. *Towards a New Forestry*. Am. For.
- Holm-Nielsen LB, Nielsen IC and Balsev H. (eds.) 1989. *Tropical Forests*, Academic Press, London.
- Pukkala T and Gadow KV. 2012. *Continuous Cover Forestry*. 2nd Edition Springer.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.
- Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture: Applied Forest Ecology*. John Wiley & Sons.

SAF 614

PLANTATION FOREST PRODUCTIVITY

1+1

Theory:

UNIT I

Plantation forests - scope and perspectives, international and national scenario.

UNIT II

Dynamics of plantation growth – site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency, nutrient pools and dynamics, biological factors in nutrient supply.

UNIT III

Advances in site preparation techniques. Recent trends in fertilization and irrigation of plantations. Tending and cultural operations and plantation productivity - prospects of mechanization in tropical plantations. Reduced impact logging. Clonal forests, their management and productivity comparisons.

UNIT IV

Productivity decline in plantation forests – second rotation decline - harvest related resource export - Modern silvicultural interventions.

UNIT V

Project formulation, designing and appraisal of different kinds of plantations to meet specific objectives.

Practical

Plantation productivity analysis – growing stock and MAI assessment - stand density estimation, fertilizers and fertilizer application in plantation, response of plantation to irrigation, productivity of clonal forestry, modern tools in site preparation, weed management methods, management strategies for enhancing plantation productivity.

Suggested Readings

Evans J and Turnbull JW. 2004. *Plantation Forestry in the Tropics: The Role, Silviculture and Use of Planted Forests for Industrial, Social, Environmental and Agroforestry Purposes*. OUP Oxford.
Evans J. 1982. *Plantation Forestry in the Tropics*. Clarendon Press.

Ford ED. 1984. *Nutrition of Plantation Forests*. Academic Press.

Krishnapillay B. 2000. *Silviculture and Management of teak plantations*. Unasy. 201. 51:14-21p.

Nambiar EKS, Cossalter C and Tiarks A. 1998. *Site Management and Productivity in Tropical Plantation Forests*. Workshop Proceedings, South Africa.

Sairil PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM. 1980. *The Practice of Silviculture*. 8th ed., John Wiley & Sons.

Suzuki K, Ishii K, Sakurai S and Sasaki S. 2006. *Plantation Forestry in the Tropics*. Springer Tokyo.

Zobel BJ, Wyk G and Stahlper P. 1987. *Growing Exotic Forests*. John Wiley & Sons.

Theory**UNIT I**

Planning for regeneration, setting the objectives for regeneration, principles and methodologies of forest regeneration, ecological basis of natural regeneration techniques.

UNIT II

Basic Concepts in forest regeneration, importance of different combinations of light, moisture, soil in determining success or failure of regeneration. Factors affecting natural and artificial regeneration- kinds, extent and quality of sites.

UNIT III

Techniques of canopy manipulation and forest continuum in regular and irregular forests canopy, light pattern and regeneration establishment. Regeneration survey and methodology. Major silvicultural systems of tropical and temperate parts of the world. Continuous cover forestry. Advances in coppice silviculture. Silviculture in a changing world.

UNIT IV

Advances in artificial regeneration techniques, advances in vegetative propagation techniques like mini and micro-cutting techniques, production technology for quality planting stock, carbon enrichment techniques for production of quality planting stock. Integrated nutrient management in nursery production. Plant quality assessment tools. Nursery production system of important timber and Non-Timber Forest Products, NTFP's yielding species in the region.

UNIT V

Sustainable site establishment practices, Novel tree establishment techniques. Regeneration problems of important conifers and broad leaved species-case studies.

Practical

Factors affecting natural and artificial regeneration, Advances in vegetative propagation techniques like mini and micro-cutting techniques, Production technology for quality planting stock, Carbon enrichment techniques for production of quality planting stock, Integrated nutrient management in nursery production. Novel tree establishment techniques. Modern approaches in containerized seedling production.

Suggested Readings

Colak AH, Rotherham ID and Calikoglu M. 2003. *Combining 'naturalness concepts' with close-to-nature silviculture*. Forstwiss. Centralbl. 122, 421–431.

Sairll PS, Evans J, Auclair D and Flack J. 1997. *Plantation Silviculture in Europe*. Oxford University Press.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture: Applied Forest Ecology*. John Wiley & Sons.

SAF 616 AGROFORESTRY FOR SUSTAINABLE AGRICULTURE 1+0

Theory

UNIT I

Current Agricultural scenario in India. Sustainable agriculture: issues and challenges. Land use changes- agroforestry: an opportunity for sustainability and rainfed agriculture.

UNIT II

Agroforestry options for sustainable agriculture: integration of perennial components in agriculture. Role of trees in enhancing the productivity of traditional agriculture. Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. Tree management for productivity optimization.

UNIT III

Agroforestry for different land holdings. Integrated farming systems. Agroforestry strategies for short term and long term returns.

UNIT IV

Processing, value addition and marketing of agroforestry products.

Suggested Readings

Chin K Ong, Colin Black and Julia Wilson. 2015. *Tree-Crop Interactions*, 2nd Edition: Agroforestry in a Changing Climate. CAB International ICRAF.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*.

Schroth G and Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods*. CABI, Wallingford, UK.

Snelder DJ and Lasco RD. 2008. *Smallholder Tree Growing for Rural Development and Environmental Services*. Springer Science, Amsterdam.

SAF 621 AGROFORESTRY RESEARCH AND MANAGEMENT 2+0

Theory

UNIT I

Recent trends in agroforestry research and development. Agroforestry land use systems and their salient features. Research designs and analysis in agroforestry. Multi-functionality of agroforestry

systems-multiplicity of products and services, food and nutritional security, livelihood security, gender related aspects. Constraints in agroforestry research - research prioritization.

UNIT II

Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations.

UNIT III

Introduction to on-farm and on-station research experiments. Biomass production and allocation patterns- changes thorough agroforestry interventions.

UNIT IV

Belowground dynamics- role of fine roots in agroforestry productivity. Tree husbandry practices in agroforestry for productivity optimization. Soil-site sustainability and environmental resource sharing. Site-species compatibility. Competition, predation, mutualism, commensalisms. Simulation modeling of agroforestry systems.

UNIT V

Carbon and nutrient dynamics in agroforestry- carbon sequestration- carbon credits- mitigatory and adaptive roles of agroforestry in the context of climate change- climate negotiations and agroforestry.

UNIT VI

Management of multifunctional agroforestry – sustainability, links with UNFCCC, UNCCD and UNCBD. Carbon conservation, sequestration, and substitution functions of agroforestry trees. Domestication of useful species and crafting market regimes for the products derived from agroforestry and ethno-forestry systems. Contract fuel wood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations. Climate change and reforestation incentive policies.

UNIT VII

Market intelligence for agroforestry products. Agroforestry value chain models: consortia concepts. Successful case studies.

Suggested Readings

- Chin K Ong, Colin Black, Julia Wilson. 2015. *Tree-Crop Interactions*, 2nd Edition: Agroforestry in a Changing Climate. CAB International.
- Kumar BM and Nair PKR. 2011. *Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges*. Springer.
- Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.
- Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.
- Snelder DJ. and Lasco RD. 2008. *Smallholder Tree Growing for Rural Development and Environmental Services*. Springer Science, Amsterdam.

SAF 622 PRODUCTIVITY AND EVALUATION OF AGROFORESTRY SYSTEMS 2+1

Theory

UNIT I

Concept of crop productivity. Productivity potential in relation to light, water and nutrients.

UNIT II

System complementarity, supplementarity, competitiveness, sustainability and management techniques. Tree root architecture, re-allocation of resources within the plant system.

UNIT III

Biological yield and harvest index. Growth and yield functions. Land equivalent ratio. Water use efficiency, photosynthetic efficiency, radiation balance, canopy transmissivity, canopy management, plant geometry and crop yield.

UNIT IV

Allelopathic effects. Strategies to improve the efficiency and productivity of different land use systems.

UNIT V

Role of various financing agencies in agroforestry and critical evaluation of different credit systems with emphasis on agroforestry. Methodologies for evaluating agroforestry hedonic pricing, PES, LER and LEV.

UNIT VI

Financial, economic and social accounting of agroforestry projects. Advances in marketing management of agroforestry products. Evaluating combined productivity and profitability of different agroforestry systems *vis-a-vis* other competitive agro-based systems. Tree insurance schemes.

Practical

Techniques for leaf area index, photosynthetically active radiation, soil moisture and leaf water potential and canopy density measurements. Exercises on developing alternative optimal agroforestry plans under perfect and imperfect knowledge situations. Socio-economic and financial evaluation of agroforestry projects.

Suggested Readings

Alavalapati JRR and D Evan Mercer. 2004. *Valuing Agroforestry Systems: Methods and applications*, Kluwer Academic Publishers.

Kant Shashi and Janaki Alavalapati. 2014. *Handbook of Forest Resource Economics*, Publisher: Routledge.

Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer.

Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF.

Sullivan, Gregory M, Susan M Hoke and Jefferson M Fox (editors). 1992. *Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July 1991*. Paia, Ill: Nitrogen Fixing Tree Association.

Tejwani KG 1994. *Agroforestry in India* Oxford and IBH publishing Co. Pvt.Ltd.

SAF-623 AGROFORESTRY FOR ECOSYSTEM SERVICES AND ENVIRONMENTAL BENEFITS 2+0

Theory

UNIT I

Multifunctionality of agroforestry. Major ecosystem services and environmental benefits and international conventions and charters on climate change (UNFCCC, UNCCD, agroforestry and climate change negotiations: CoP) and biodiversity conservation (CBD) – an overview.

UNIT II

Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems. Estimates of carbon sequestration potential – measurement - prospects and problems. Factors affecting above and belowground carbon sequestration potential.

UNIT III

Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N₂ fixation, mycorrhizal associations. Soil and water conservation benefits.

UNIT IV

Agroforestry for biodiversity conservation. Synergy with climate change mitigation. Landscape connectivity for wildlife, supporting the pollinators of plant species. Agroforestry for improved air and water quality. Non-point source pollution in Indian agro-ecosystems. Riparian buffers for alleviating agricultural non-point source pollution.

UNIT V

Private profitability vs. social profitability - exclusion or inclusion of social benefits and costs and non-market values, or externalities. Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices. Valuing environmental services. Profitability of timber-based agroforestry systems. Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs.

Suggested Readings

- Alavalapati JRR, Shrestha RK, Stainback GA and Matta JR. 2004. *Agroforestry development: An environmental Economic Perspective. Agroforestry Systems*. 61: 299–310.
- Huxley P. 1999. *Tropical Agroforestry*. Blackwell.
- IPCC. 2007. *Climate Change 2007. Mitigation of Climate Change*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- Jain SK and Singh P. 2000. *Economic Analysis of Industrial Agroforestry: Poplar (Populus deltoides) In Uttar Pradesh (India). Agroforestry Systems*. 49: 255–273.
- Jeffers JNR. 1978. *An Introduction to System Analysis with Ecological Application*. Edward Arnold.
- Jose S. 2009. *Agroforestry for Ecosystem Services and Environmental Benefits: An Overview. Agroforestry Systems*. 76: 1-10.
- Lyngbaek AE, Muschler RG and Sinclair FL. 2001. *Productivity and Profitability of Multistrata Organic Versus Conventional Coffee Farms in Costa Rica. Agroforest. Syst.* 53: 205–213.
- Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.
- Schroth G and Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods*, CABI, Wallingford, UK.

SAF-624

RESTORATION FORESTRY

1+0

Theory

UNIT I

Introduction to restoration forestry, scope and opportunities for forest restoration, Natural regeneration, forest and land degradation in the Asia-Pacific region. Forest restoration techniques, tools for prioritization, decision-making and monitoring to enhance restoration success, The Bonn Challenge, The Bonn Challenge in Asia, Africa and Latin America.

UNIT II

Forest landscape restoration, environment for natural regeneration in forest and landscape restoration, economic and social aspects for successful integration of natural regeneration in forest landscape restoration, adaptive management for forested landscapes in transformation, measures to improve resilient and genetically diverse forests. Mangrove restoration.

UNIT III

Case studies on successful forest landscape restoration.

Suggested Readings

Beatty CR, Cox NA and Kuzee ME. 2018. *Biodiversity Guidelines for Forest Landscape Restoration Opportunities Assessments*. First edition. Gland, Switzerland: IUCN.

Blakesley D and Buckley P. 2016. *Grassland Management and Restoration*. Conservation handbooks. Pelagic Publishing. Food and Agriculture Organization of the United Nations.

Chokkalingam U, Shono K, Sarigumba MP, Durst PB and Leslie R. (eds). 2018. *Advancing the Role of Natural Regeneration in Large-Scale Forest and Landscape Restoration in the Asia-Pacific Region*. FAO and APFNet. Bangkok.

FAO. 2010. *Forests Beneath the Grass*. Proceedings Of The Regional Workshop On Advancing The Application Of Assisted Natural Regeneration For Effective Low-Cost Forest Restoration. Bangkok, FAO.

FAO/RECOFTC. 2016. *Forest Landscape Restoration in Asia-Pacific Forests*. by Appanah, S. (ed.). Bangkok, Thailand. 198p

Prober SM, Byrne M, McLean EH, Steane DA, Potts BM, Vaillancourt RE and Stock WD. 2015. *Climate-Adjusted Provenancing: A Strategy for Climate-Resilient Ecological Restoration*. Frontiers in Ecology and Evolution, 23 June.

Theory**UNIT I**

Forest soils and vegetation development. Physical properties of forest soils. Forest soil classification. Soils of the major forest biomes – soils under different forest types - tropical rainforest soils – moist deciduous forests – dry deciduous. Soils and plant roots.

UNIT II

Soil chemistry and nutrient uptake. Soil organic matter - maintenance and buildup. Biology of forest soils - role of microorganisms in ameliorating soils; N and C cycles. Forest biogeochemistry. Micorrhizae. Role of forests in conserving soils.

UNIT III

Nutrient transformation in soils. Nitrogen fixation in tropical forest plantations: N₂ fixation process, species, rates of N₂ fixation, factors influencing N₂ fixation; nutrient cycling - comparison of plantation productivity - case studies. Nutrition management: nutrient limitations, fertilization. Soil carbon sequestration - processes and mechanisms.

UNIT IV

Soil management for reforestation of salt affected soils, acid soils, coastal soils. Effects of fire on soils and their properties.

UNIT V

Management of long term soil productivity - soil compaction and erosion - harvest removal and nutrient budgeting - harvest effect on water quality - strategies for future management.

Practical

Nutrient budgeting for different plantation systems, quantification of physical and chemical soil constraints in plantation and agroforestry systems, evolving new strategies for soil and site development.

Suggested Readings

Binkley D and R. Fisher. 2012. *Ecology and Management of Forest Soils* (4th Edition), John Wiley & Sons Singapore Pte. Ltd., Singapore.

Fisher RF, Binkley D and Pritchett WL. 2000. *Ecology and Management of Forest Soils*. 3rd Ed. John Wiley & Sons Inc., New York.

Havlin *et al.* 2014. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management* (8th Edition), PHI Learning Pvt. Ltd., Delh

Khan TO. 2013 *Forest Soils: Properties and Management*, Springer International Publishing, Switzerland.

Pritchett and Fisher RF 1987. *Properties and Management of Forest Soils*. John Wiley, New York.

- Reddy MV. 2001. *Management of Tropical Plantation Forests and Their Soil Litter System-Litter, Biota and Soil Nutrient Dynamics*. Science Publishers, U. S.
- Sadanandan Nambiar EK and Grown AG. (Eds.). 1997. *Management of Soil, Nutrients and Water in Tropical Plantation Forests*. ACIAR, CSIR and CIFOR, Australia.
- Schulte A and Ruhiyat D. 1998.** *Soils of Tropical Forest Ecosystems: Characteristics, Ecology, and Management*. Springer Verlag, Berlin, New York.

(iv) Ph.D. (Forestry) Forest Biology and Tree Improvement

Major Courses

Course Code	Semester	Course Title	Credit Hrs.
		Semester I	

FBT-611*	I	Special Topics in Tree Improvement	2+1
FBT-612*	I	Biometrical Genetics	2+1
FBT-613	I	Molecular Genetics of Forest Trees	2+1
FBT-614	I	Tree Physiology and Forest Productivity	2+1
		Semester II	
FBT-621	II	Forest Genetics and Tree Breeding	2+0
FBT-622	II	Forest Tree Reproduction	2+1
FBT-623	II	Genetics of Forest Ecosystems and Conservation Biology	3+0
FBT-624	II	Tree Seed Management	1+1

***Compulsory Core Courses**

FBT-611 SPECIAL TOPICS IN TREE IMPROVEMENT 2+1

Theory

UNIT I

Mendelian concepts as applied to forest trees. Cytological and chromosomal systems of forest trees. Cytoplasmic inheritance in trees. Colchiploid and mutation breeding for forest trees.

UNIT II

Tree domestication for small-scale farmers: needs, criteria and selection methods . Choosing the right tree. Participatory rural appraisal approaches. Ethnobotanical methods. Species priority setting procedures. Value chain analysis. Participatory tree domestication approach.

UNIT III

Physiological basis of tree improvement. Pollution responses of trees. Pollen handling and hybridization techniques in forest trees. Tissue culture of trees.

UNIT IV

Molecular genetics as applied to forest trees, recent trends in tree improvement, somatic hybrids, transformation, gene sequencing. Inheritance of monoterpene composition in conifers.

UNIT V

Indirect selection for improvement of desired traits, molecular markers. Juvenile traits and their role in genetic evaluation in tree improvement programmes.

UNIT VI

Geographic variation in trees, evolution and gene flow. Exploration and conservation of gene resources of trees. Dioecism and monoecism in trees.

Practical

Cytology of pine root tips, karyotypic analysis, mutagenic treatments with colchicine and MH, tissue culture of organs and transformation experiments, resin tapping and observation of trees for monoecism and dioecism.

Suggested Readings

Ramawat KG, Merillon JM and Ahuja MR. 2014. *Tree Biotechnology*. CRC Press.

Schnell RJ and Pridarshan PM. 2012. *Genomics of Tree Crops*, Springer.

White TL, Adams WT and Neale DB. 2007. *Forest Genetics*. CABI.

FBT-612

BIOMETRICAL GENETICS

2+1

Theory

UNIT I

Concepts in quantitative genetics, quantitative inheritance, historical aspects, Galton (1869) methods for studying quantitative traits, qualitative and quantitative traits and their inheritance, property of nuclear genes (segregation and linkages). Linkage between major gene and polygenes. Evidence that quantitative trait is inherited in Mendelian fashion. Nilsson-Ehle (1908) multiple factor hypothesis. East (1916) experiment on *Nicotiana longifera*.

UNIT II

Genetic components of continuous variation gene models (additive, dominance, epistasis) features of additive gene action, features of non-additive gene action, genetic variance in F_2 population in various gene models. Important principles established by NCSU (North Carolina State University) for forest tree improvement, origin of variation, estimation of hereditary parameters, variance derivation in F_2 and backcrosses. Genotype X environment interaction, its measurement and significance. Concepts of heritability and genetic advance. Random mating in forest trees, their population structure and response to selection.

UNIT III

Quantitative genetics in relation to efficient breeding methodology – partitioning of means and variances, simple scaling and joint scaling tests. Line X tester analysis and diallel analysis mating designs in tree improvement, incomplete pedigree design and complete pedigree design.

UNIT IV

Usefulness of biometrical techniques. Assessment of variability, variance analysis, metroglyph analysis, D^2 statistic. Aids to selection correlation, path analysis, discriminant function. Aids to choice of parents: Assessment of adaptability, stability analysis, software in forest genetic analysis and their interpretation.

UNIT V

Molecular diversity analysis, methods for mapping QTL.

Practical

Genotypic and phenotypic variance in forest trees. Detection of linkage in coupling. Proof that gene and genotypic frequencies remain constant in random mating populations. Stability analysis- Eberhart and Russell Model (1966)- Perkins and Jinks Model (1971). Problems on demonstrating the effects of selection, mutation, migration and genetic drift in random mating population through graphs. Simple scaling tests. Joint scaling tests. Heritability estimation (Analysis of variance, parent offspring correlation and regression). Heritability in narrow sense estimation. Line X Tester analysis. Diallel analysis

Calculation of genotypic and phenotypic correlations. Path analysis. Discriminant function. D^2 Statistics. Principal component analysis. Diversity analysis based on RAPD/ SSR

Suggested Readings

Mather K and Jinks JL. 1971. *Biometrical Genetics*. Champman and Hall, London.

Singh RK and Chaudhary BD.1985. *Biometrical Methods in Quantitative Genetical Analysis*. Kalyani Publishers, New Delhi.

White TL, Adams WT and Neale DB. 2007. *Forest Genetics*. CABI.

FBT-613 MOLECULAR GENETICS OF FOREST TREES

2+1

Theory

UNIT I

Biochemical markers (Isozymes and Monoterpenes). Molecular markers – Non-PCR based (RFLP) and PCR based (RAPD, ISSR, SSR, AFLP, SNP etc.). Application in forestry – quantification of genetic diversity. Marker assisted selection. Genetic maps of selected forest trees.

UNIT II

DNA sequencing. Structural genomics. Functional genomics. Transcriptomics. Proteomics. Metabolomics.

UNIT III

Recombinant DNA Technology, Transgenics, Vectors,. Gene transfer strategies – direct and indirect. Molecular characterization of transformants. Application of transgenics in forestry.

Practical

Isolation of DNA, RNA from forest tree species, isozyme analysis, use of molecular markers and RAPD and RFLP for clonal identification. *Agrobacterium* mediated gene transfer. Preparation of linkage maps.

Suggested Readings

Brown CM, Campbell I and Preist FG. 2005. *Introduction to Biotechnology*. Panima Publishers.

Chawla HS. 2004. *Introduction to Plant Biotechnology*. Kalyani Publishers.

Kole C 2007. *Genome Mapping and Molecular Breeding in Plants*. Springer.

Schnell RJ and Pridarshan PM. 2012. *Genomics of Tree Crops*. Springer.

Singh BD. 2006. *Biotechnology – Expanding Horizons*. Kalyani Publishers.

FBT-614 TREE PHYSIOLOGY AND FOREST PRODUCTIVITY

2+1

Theory

UNIT I

Introduction, tree forms in relation to environmental factors mechanism responsible for differences in tree forms stand structure and micro-climate.

UNIT II

Carbon fixation by tree canopies, leaf area, interception of solar radiation and tree growth. Leaf area index and dry matter production. Radiation attenuation through canopies strategies for maximising solar energy utilization, stomatal conductance.

UNIT III

Carbon consumption and export, carbon balance in trees, canopy photosynthesis. Transport and partitioning. Factors influencing net photosynthesis in trees. Relationship between the CO₂ compensation point and carbon fixation efficiency in trees. Physiology of formation of early and late woods. Resource sharing in mixed agroforestry system .

UNIT IV

Evapo-transpiration factors affecting evapo-transpiration. Potential evapo-transpiration. Moisture stress, osmotic adjustment stomatal response to moisture stress. Water use efficiency drought tolerance

UNIT V

Biochemical and molecular aspects, water logging, physiology of resistance to water logging. Salt and ion stress.

UNIT VI

Avoidance and tolerance mechanisms. Temperature stress, low temperature stress, physiology of resistance to frost. Heat stress, heat injury, heat avoidance and tolerance mechanism, Radiation stress, mechanism of shade tolerance, Physiological basis of pollution stress, Ozone injury Acid rain, Heavy metals.

Practical

Chlorophyll stability index. Leaf water potential by pressure bomb technique - porometry steady state porometer. Leaf temperature, transpiration rate. Stomatal resistance and conductance. Seed germination test for drought, tolerance and pre-treatment of seeds for drought tolerance. Water use efficiency. Measurement of photosynthesis.

Suggested Readings

Kozlowski TT. 1971. *Growth and Development of Trees*. Vol. I. Academic Press.

Kramer PJ and Kozlowski TT. 1979. *Physiology of Woody Plants*. Academic Press.

Ksenzhek OS and Volkov AG. 1998. *Plant Energetics*. Academic Press, New York.

Lack AJ and Evans DE. 2001. *Plant Biology- Instant Notes*. Vina Books Pvt. Ltd., New Delhi.

Larcher W. 2003. *Physiological Plant Ecology*. 4th edn, Springer-Verlag, Germany.

- Luttge U. 2008. *Physiological Ecology of Tropical Plants*. Springer-Verlag, Germany Mandal AK and Gibson GL. 1997. *Forest Genetics and Tree Breeding*. CBS.
- Raghavendra AS. 1991. *Physiology of Trees*. John Wiley & Sons.
- Taiz L and Zeiger E. 2007. *Plant Physiology* 4th Ed. Sinauer Associates Inc. Publishers, Sunderland.
- Zimmerman RH. 1972. *Juvenility and Flowering in Woody Plants: A Review*. Hort. Science 7(5): 447-455.
- Zimmermann MH and Brown CL. 1971. *Trees Structure and Function*. Springer Verlag.

FBT-621 FOREST GENETICS AND TREE BREEDING

2+0

Theory

UNIT I

Taxonomy and phylogenetic studies. Assessment of genetic diversity, gene conservation, breeding populations: long term and short term, pollen collection storage, extension, theories of pollen dispersal, mating designs. Polygenic inheritance, genetics of heterosis, overcoming incompatibility, hybrid embryo rescue and studies in hybrid development in forest trees.

UNIT II

Molecular breeding- constructing molecular map. Integrating genetic, physical and molecular maps. Diversity assessment and phylogenetic analysis. Molecular tagging of genes/traits. Selected examples on marker assisted selection of qualitative and quantitative traits. Application of molecular markers and genomic tools for the genetic enhancement.

Suggested Readings

- Khosla PK. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.
- Mandal AK and Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS.
- Nanson A. 2004. *Genetics of Forest Tree Breeding*. Agronomic Press.
- Schnell RJ and Pridarshan PM. 2012. *Genomics of Tree Crops*, Springer.
- Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. *A Text Book of Forest Tree Breeding*. ICAR.
- Suzuki D, Gryfiths AJF, Miller JH and Lewontin RC. 1986. *An Introduction to Genetic Analysis*.
- Wright JW. 1976. *Introduction to Forest Genetics*. Academic Press.

FBT-622 FOREST TREE REPRODUCTION

2+1

Theory

UNIT I

Reproductive biology of gymnosperms and angiosperms, Reproduction and population genetic structure, population dynamics. Floral morphology, floral initiation and breeding systems. Flowering manipulation. Reproductive abnormalities.

UNIT II

Pollination, biology, pollination ecology of tropical and temperate forest tree species, plant-pollination interactions. Pollinator energetic and nectar production.

UNIT III

Genetic consequences of variation in reproductive biology. Pollen biotechnology for improved production.

UNIT IV

Gene expression during pollen development. Pollination efficiency of insects. Self-incompatibility.

Practical:

Phenological studies in forest trees, nectar collection and analysis, pollination trapping distances, foraging behaviour, pollinator identification and visitation.

Suggested Readings

Barrett SCH. 2006. *Ecology and Evolution of Flowers*. [electronic resource]. (Eds.) L.D. Harder SCH. Barrett. Oxford Univ. Press, New York, U.S.A.

Bawa KS and Hadley M. 1990. *Reproductive Ecology of Tropical Forest Plants*. UNESCO Man and Biosphere series.

Briggs and Walters Sm. 1984. *Plant Variation and Evolution*.

Cláudia Inês da Silva and Helena Maura Torezan Silingardi. 2006. *Reproductive Biology of Tropical Plants*. International Commission on Tropical Biology and Natural Resources. Encyclopedia of Life Support Systems (EOLSS).

FAO. 1985. *Forest Tree Improvement*, FAO Publication.

Khosla PK. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.

Mandal AK and Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS.

Sedgley M and Griffin A R. 1989. *Sexual Reproduction of Tree Crops*. Academic Press.

Spencer CH, Barrett, Robert I, Colautti and Christopher G Eckert. 2007. *Plant Reproductive Systems and Evolution during Biological Invasion*. Wiley Online Library.

FBT-623 GENETICS OF FOREST ECOSYSTEMS & CONSERVATION BIOLOGY

3+0

Theory

UNIT I

What is ecological genetics, uses of ecological genetics, markers and sampling in ecological genetics, genetic diversity and differentiation, gene flow and mating system, intraspecific phylogenies and phylogeography, speciation and hybridization.

UNIT II

The ecological niche, adaptations, genetic systems, adaptive strategies, forest ecosystems, how man affects forest ecosystems manmade forest ecosystems.

UNIT III

Carbon sequestration consumption and export - carbon balance in trees – canopy photosynthesis - Transport and partitioning. Factors influencing net photosynthesis in trees. Relationship between

the CO₂ compensation point and carbon fixation efficiency in trees. Physiology of formation of early and late woods-resource sharing in mixed agroforestry system.

UNIT IV

Evapo-transpiration - factors affecting evapo-transpiration potential evapo-transpiration. Moisture stress - osmotic adjustment stomatal response to moisture stress water use efficiency drought tolerance.

UNIT V

Forest as biological community, Amplification of conceptual and quantitative models of variation in trees.Changes in gene frequencies genetics and theory of selections adaptations and conservation. Gene flow and genetic drift, polymorphism. Population structure and migration.

UNIT VI

Conservation biology: Introduction, Conservation biology—past and present. Biodiversity. Defining and measuring biological diversity. Threats to biodiversity. Computing biological diversity. Biological hot spots. Social value and the role of people in conservation. Ecosystem functions and services. Habitat destruction. Habitat fragmentation and landscape changes. Over harvesting. Invasive species impacts. Climate change. Population viability analysis. Application of population ecology to conservation biology for fauna and flora. Population and conservation genetics practical examples in conservation of plants and animals. Landscape ecology and conservation practices. Conservation planning and priorities. Single and Multi species conservation strategies. Endangered species management. Restoration and species recovery planning. Community biodiversity management. Strategic species concepts (Keystone species. Indicator species. Umbrella and flagship species) concept of sustainable development.

Suggested Reading

Klaus Stern and Laurence Roche. 1974.Genetics of Forest Ecosystems.**New York a.o. Springer-Verl.**

Kozlowski TT. 1971. *Growth and Development of Trees*. Vol. I. Academic Press.

Kramer PJ and Kozlowshi TT. 1979. *Physiology of Woody Plants*. Academic Press.

Larcher W. 1980. *Physiological Plant Ecology*. Springer-Verlag.

Lowe A, Harris S and Ashton P. 2004. *Ecological Genetics: Design, Analysis and Application* Oxford: Blackwell Publishing.

Raghavendra AS. 1991. *Physiology of Trees*. John Wiley & Sons.

Weathers. 2013. *Fundamentals of Ecosystem Science*. . M/s. International Books & Periodicals Supply Service, Pitampura, Delhi.

Zimmerman RH. 1972. *Juvenility and Flowering in Woody Plants: A Review*. *Hort. Science* 7(5): 447-455.

FBT-624

TREE SEED MANAGEMENT

1+1

Theory

UNIT I

Concepts, classification, seed fortification, use of adjuvants, diluents, stickers, encapsulation materials, dyes, chemicals, pesticides, fungicides, animal repellents, biological materials, antibiotic and growth regulators, biofertilizers, minerals salts, bioactive substances.

UNIT II

Seed infusion and involvement in synergistic factors dormancy and stratification, Physical treatment with abrasives, hot and cold temperature, radio, frequency waves, UV rays, X-rays and gamma rays.

UNIT III

Methods of application and their effects on germination, seed hardening, osmotic priming in relation to stress management.

UNIT IV

Seed pelleting, use of bio-fertilizers, mineral salts, growth regulators, hydrophilic substances, seed-coat polymers in stress management, sequences in seed inoculation.

UNIT V

Planting value determination and storage potential evaluation, aerial seeding and its implication, use of IDS for separation of viable seed from non viable seeds mid-storage correction treatment.

Practical

Influence of seed fortification with different treatments on germination and vigour of seeds. Studies on seed infusion effects on germination. Vigour and planting value. Use of physical treatment of seeds on seed germination and vigour. Seed hardening treatments and their influence on the planting value of seeds. Studies on osmotic priming on stress tolerance of seedlings. Seed pelleting studies in tree seeds. Evaluation of pelleted seeds for survival percentage both in laboratory and field. Determination of storage potential of pelleted seeds. Use of organic solvents for seed infusion and their influence on the seed quality. Standardization of IDS method to separate viable seeds from non-viable seeds in tree species. Evaluation of effectiveness of separation by IDS method by germination test, cutting test radiographic analysis. Studies on the evaluation of mid-storage correction treatments on the viability and vigour of seeds in storage by accelerated aging test.

Suggested Readings

Dutta M and Saini GC. 2009. *Advances in Forestry Research in India*, Vol. XXX. *Forest Tree Improvement and Seed Technology*. International Book Distributors.

Khullar P, Thapliyal RC, Beniwal BS, Vakshasya and Sharma A. 1991. *Forest Seeds*. ICFRE.

Lars H Schmidt. 2000. *Guide to Handling of Tropical and Subtropical Forest Seeds*. Danida Forest Seed Centre.

Mema NP. 1989. *Principles of Seed Certification and Testing*. Allied Publ.

Negi SS. 2008. *Forest Tree Seeds*. International Book Distributors.

Ram Prasad and Kandya R K. 1992. *Handling of Forestry Seeds in India*. Associated Publ.

Vanangamudi K. 2007. *Advances in Seed Science and Technology*, Volume IV. Agrobios (India).

(v) Ph.D. (Forestry) Forest Products and Utilization
Major Courses

Course Code	Course Title	Credit Hrs.

	Semester I	
FPU-611*	Developments in Wood and Non-Wood Forest Products	3+0
FPU-612	Wood and Wood Technology	2+1
FPU-613	Chemistry of Medicinal and Aromatic Plants	2+1
FPU-614	Value Addition and Marketing of Forest Products	2+1
FPU-615	Development in Pulp and Paper Technology	2+0
FPU-616	Production of Quality Planting Material of Medicinal and Aromatic Plants	2+1
FPU-617	Biosynthesis of Secondary Metabolites	3+0
	Semester II	
FPU-621 *	Analytical Techniques in Forest Products	1+2
FPU-622	Energy and Chemicals from Wood	2+0
FPU-623	Processing Technology of Forest Products	2+1
FPU-624	Modern Trends in Wood Modification	2+1
FPU-625	Application of Traditional Knowledge	2+0
FPU-626	Processing Technology of Medicinal & Aromatic Plants	2+1
FPU-627	Value Additions and Marketing of Medicinal & Aromatic Plants	2+1

***Compulsory Core Courses**

FPU-611 DEVELOPMENTS IN WOOD AND NON-WOOD FOREST PRODUCTS

3+0

Theory

UNIT I

Mechanics of wood and wood composites, Application of orthotropic and non-linear constitutive relations, Laminate theory and failure criterion in the prediction of mechanical properties of solid woods; Wood-polymer; Hybrid composite processing.

UNIT II

Principles of industrial wood processes, products derived from wood by chemical processes and value added wood products, properties of construction, Wood polymers and surface chemistry, fundamentals of adhesion and fracture in adhesively bonded wood, adhesive systems used for wood with emphasis in wood based composites.

UNIT III

Methods of extraction, chemistry, processing, import and export potential of gums, resins, tannins, dyes, essential oils, fixed oils, cutch and katha, drugs, spices, poisons, insecticides, pesticides, wild edible fruits, etc.

UNIT IV

Computer application system in forest products, Use of information technologies to integrate material, quality and market fluctuations.

Suggested Readings

Arnason JT, Rachel M and Romeo JT. 1995. *Phytochemistry of Medicinal Plants*. Springer, US.

Bowyer JL, Shmulsky R and Haygreen JG. 2003. *Forest Products and Wood Science: An Introduction*. 4th Ed. Blackwell Publishing.

Chung and Deborah DL. 2003. *Composite Materials-Functional Materials for Modern Technologies*. Springer, Verlag London.

David AT. 2013. *Forest Products: Advanced Technologies and Economic Analyses*. Elsevier.

Linskens HF and Jackson JF. 1991. *Essential Oils and Waxes (Ed.)*. Springer-Verlag Berlin Heidelberg.

Mathe A. 2015. *Medicinal and Aromatic Plants of the World-Scientific, Production, Commercial and Utilization Aspects*. Springer Netherlands.

Panda H. 2005. *Hand Book on Specialty Gums, Adhesive, Oils, Rosin and Derivatives, Resins, Oleoresins, Katha, Chemicals with others Natural Products*. Asia Pacific business press. Inc.

Rojas OJ. 2016. *Cellulose Chemistry and Properties: Fibers, Nanocelluloses And Advanced Materials (Ed.)*. Springer International Publishing.

Rowell RM. *Hand Book of Wood Chemistry and Wood Composites*. 2013. CRC press, Taylor and Francis group.

Shackleton S, Shackleton C and Shanley P. 2011. *Non-Timber Forest Products in the Global Context (Ed.)*. Springer, Verlag Berlin Heidelberg.

Sharma LC. 2012. *Development of Forests and Forest Based Industries*. M/s Bishen Singh Mahendra Pal Singh.

FPU-612

WOOD AND WOOD TECHNOLOGY

2+1

Theory

UNIT I

Ultrastructure and composition of softwoods and hardwoods.

UNIT II

Transverse, volumetric and longitudinal shrinkages in wood

UNIT III

Biopulping, enzyme pulp bleaching, biotechnological production of wood composites, bioremediation of wood treated with preservatives, bioactive wood polymer composites, non-conventional wood bonding, wood degradation by chemicals, treatment of pulp effluents.

Practical

Study of major cell types of softwoods and hardwoods. Cell inclusions. Shrinkage and swelling of wood. Determination of anti-shrink efficiency of treated wood. Pulping, pulp yield and bleaching.

Suggested Readings

Bowyer JL Shmulsky R and Haygreen JG. 2010. *Forest Products and Wood Science: An Introduction*. 4th Ed. Blackwell Publishing.

David A and Talliman. 1978. *Wood as an Energy Resource*. Academic Press.

Hills WE. 1982. *Heartwood and Tree Exudates*. Springer Verlag.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press, Taylor and Francis Group.

Shmulsky RP and David. 2011. *Forest Products and Wood Science: An Introduction*. 6th Ed. Wiley, Blackwell.

Sjostrom E. 1993. *Wood Chemistry: Fundamentals and Applications*. 2nd Ed. Gulf Professional Publishing.

FPU 613 CHEMISTRY OF MEDICINAL AND AROMATIC PLANTS 2+1

Theory

UNIT I

Detail study of biosynthetic pathways of terpenoides, steroids, alkaloids, phenolic compounds and amino acids

UNIT II

Chemical studies of important insecticidal compounds of plant origin. Chemical conversion of some plant products to useful drugs.

UNIT III

Nature of postharvest degradation of active principles.

Practical:

Extraction, purification, separation and structural determination of some important active principles of plants by various physical and chemical techniques. Structural determination of some important active principles of plants by various physical and chemical techniques.

Suggested Readings

Chauhan NS. 1999. *Medicinal and Aromatic Plants ff Himachal Pradesh*. Indus Publishing.

Mathe A. 2015. *Medicinal and Aromatic Plants of the World: Scientific, Production, Commercial and Utilization Aspects*. Springer.

Zohara Y and Bachrach U. 2005. *Handbook of Medicinal Plants*. CRC Press.

FPU 614 VALUE ADDITIONS AND MARKETING OF FOREST PRODUCTS 2+1

Theory

UNIT I

Value addition - concepts and procedures. Drying and grading of various forest products. Preparation of powders, aqueous and alcoholic extracts essences etc. Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging.

UNIT II

Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector. Village and regional markets, state, national and international market of forest products. Internet marketing practices for latest market value and other pattern of fluctuations for high value forest products. Concept of e-market and quality standards.

Practical

Visit to nearby pharmaceutical concern for understanding value addition processes. Visit to local market and data collection of sale and sale procedure - organized and unorganized. Internet surfing for latest market value of high value forest products.

Suggested Readings

Govil JN, Arunachalam C and Singh VK. 2006. *Recent Progress in Medicinal Plants*. Volume 11: drug development from molecules. Studium Press LLC.

Sharma AK and Singh VK, Govil JN and Goyal NK. 2006. *Recent Progress in Medicinal Plants*. Volume 12: Globalization Of Herbal Health. Studium Press LLC.

Singh MP and Somadey. 2015. *Indian Medicinal Plants*. Satish Serial Publishing House.

Singh VK, Govil JN and Singh G. 2002. *Ethnomedicine and Pharmacognosy*. Science Technology, Publishing LLC.

Syamal MM. 2008. *Production Technology of Medicinal & Aromatic Plants*. IBDC Publishers.

FPU 615 DEVELOPMENT IN PULP AND PAPER TECHNOLOGY

2+0

Theory

UNIT I

Historical development of the pulp and paper industry. Chemistry of fibrous raw material - raw material preparation.

UNIT II

Advances in pulping processes for softwood, hardwoods and other fibrous material. Recent trends in Bio-pulping, Chlorine free bleaching, organo solve pulping.

UNIT III

Nanotechnology in pulp and paper making. Substitution of wood with recycled fibers.

UNIT IV

Reduction in water utilization and effluent discharge.

Suggested Readings

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press.

**FPU 616 PRODUCTION OF QUALITY PLANTING MATERIAL OF MEDICINAL
AND AROMATIC PLANTS**

2+1

Objective

To develop understanding of students about production of quality planting material.

Theory

UNIT I

Concept of quality in the context of medicinal and aromatic plants. Quality parameters of different medicinal and aromatic plants.

UNIT II

Role of genotype and environment in affecting quality. Selection and development of hybrids in medicinal and aromatic plants.

UNIT III

Breeders seed, foundation seed and certified seed. Marker assisted breeding. Authentication of nursery produce for quality parameters. Different approaches including biotechnological tools for production of quality planting material.

Practical

Production of inbred seed of commercially important species. Selection of superior genotypes on the basis of agronomical characters from an existing population of medicinal and aromatic plants. Evaluation of germplasm for yield attributes.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants*.

Johnson CB and Franz C. 2005. *Breeding Research on Aromatic And Medicinal Plants*. International Book Distr.

Sharma R. 2004. *Agrotechniques of Medicinal Plants*. Daya Publications.

FPU 617 BIOSYNTHESIS OF SECONDARY METABOLITES**3+0****Theory****UNIT I**

Primary and secondary metabolites. Building blocks for secondary metabolites. Common reactions involved in the biosynthesis of secondary metabolites. Effect of environmental factors on production of secondary metabolites.

UNIT II

Biosynthetic pathways of terpenoids (mono, sesqui, di, tri and tetraterpenoids) and steroids.

UNIT III

Biosynthesis of alkaloids of phenylethylamine. Pyrrolidine piperidine, pyrrolidine - pyridine, tropane, quinoline, isoquinoline and phenanthrene groups.

UNIT IV

Biosynthesis of flavonoids, lignans (podophyllotoxin) and Vitamins E & K.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta K and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants*.

Mann J 1994. *Chemical Aspects of Biosynthesis*. Oxford Chemistry Primers.

Sharma R. 2004. *Agrotechniques of Medicinal Plants*. Daya Publ.

FPU 621 ANALYTICAL TECHNIQUES IN FOREST PRODUCTS**1+2****Theory****UNIT I**

Concept of spectroscopy, electromagnetic radiation, Beer-Lambert Law of electromagnetic radiation. Chemical analysis of spectrophotometry. Different spectrophotometric methods in chemical analysis. Principle and utilization of different instruments based on spectrophotometric methods- atomic absorption, spectrophotometer, IR, UV, NMR, Mass spectrophotometer etc. Chromatography and various chromatographic techniques in chemical analysis of plant samples. Principle and utilization of various chromatographic techniques and instruments- TLC, HPLC, Gas chromatography etc.

UNIT II

Principle and utilization of CHN analyzer. Physico-chemical analysis of pulp and Paper.

Practical

Estimation of volatile and non volatile chemical constituents of plants through various techniques and instruments. Estimation of different elements in plant samples. Chemical analysis of pulp. Determination of physico-chemical analysis of pulp and Paper.

Preparation of research project. Writing of research report.

Suggested Readings

Harborne JB. 1998. *Phyto-Chemical Methods*. 3rd Ed. Springer Publication, New York.

Moore WE and Johnson DB. 1967. *Procedure for Chemical Analysis of Wood and Wood Products*. Forest Products Laboratory, Forest Service US Dept of Agriculture.

Raaman N. 2006. *Phytochemical Techniques*. New India Publishing Agency, New Delhi.

Rao KP. 2003. *Pulp and Technology*. CBS Publishing and Distributors, New Delhi.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press, New York.

Rydholm SA. 1965. *Pulping Process*. Inter-science Publishers.

Snyder LR, Kirkland JJ and Glajch JL. 1997. *Practical HPLC Method Development*. 2nd Ed. John Wiley & Sons.

Wilde KD and Engewald W. 2014. *Practical Gas Chromatography: A Comprehensive Reference*. Springer, Berlin.

FPU 622 ENERGY AND CHEMICALS FROM WOOD

2+0

Theory

UNIT I

Energy and its measurements. Wood as sources of energy and its comparison with other sources. Criteria for evaluation of different fuel wood species for energy.

UNIT II

Utilization of wood waste material as fuel. Gasification, pyrolysis and briquetting of lignocellulosic material. Production of chemicals from forest biomass cellulose, lignin and hemicelluloses. Important wood extractives

UNIT III

Wood refinery techniques. Chemicals produced as by product in pulp industry.

UNIT IV

Destructive distillation of wood. Future of wood chemical industry.

Suggested Readings

Dimitris SA. 2007. *Materials, Chemicals, and Energy from Forest Biomass*. American Chemical Society.

Klass DL. 1998. *Biomass for Renewable Energy, Fuels and Chemicals*. Academic Press.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press.

Sjostrom E. 1993. *Wood Chemistry: Fundamentals and Applications*. 2nd Ed. Gulf Professional Publishing, Texas.

FPU 623 PROCESSING TECHNOLOGY OF FOREST PRODUCTS 2+1

Theory

UNIT I

Identification of harvesting period based on active content of drugs. Harvesting method of underground parts, leaves, stem, bark, wood, fruits, flowers etc.

UNIT II

Processing of harvested crops of various forest products (*e.g.* Gums, Resin, Katha, Cutch, Tans, Dyes and fixed oil). Storage and value addition. Deterioration degradation of active principles during storage and their control.

UNIT III

Isolation of major bioactive compounds. Preparation of active content enriched extracts.

UNIT IV

Latest methods of extraction of volatile and fixed oil.

Practical

Harvesting, drying, grading and packaging of various forest products. Assessment of deterioration of active principles during storage and their control. Preparation of active content enriched extracts of important forest products.

Suggested Readings

Bedi S, Singh T and Vyas SP. 2012. *A Handbook of Aromatic and Essential Oil Plants: Cultivation, Chemistry, Processing and Uses*. Agrobios (India).

Dawn CPA, Annamalai M and Naik R. 2016. *Leafy Medicinal Herbs: Botany, Chemistry, Postharvest Technology and Uses*. CABI.

Serdar O and Milan M. 2014. *Medicinal and Aromatic Crops: Harvesting, Drying and Processing*. CRC Press.

FPU 624 MODERN TRENDS IN WOOD MODIFICATION 2+1

Theory

UNIT I - Engineered wood products. Wood polymer hybrid composites. Stabilization of wood preservatives.

UNIT II -Testing of biological performance of modified wood products. Degradation of cellular structure of wood during use.

UNIT III - Environmental issues related to wood modification.

Practical

Different preservative treatments of wood. Chemical modification of wood. Testing of biological performance of modified wood. Treated wood finishing.

Suggested Readings

Ansell MP. 2015. *Wood Composites*. Elsevier-Science-Technology.

FAO. 2007. *Wood Preservation Manual*. International Book Distributor, Dehradun.

Hill CAS. 2006. *Wood Modification: Chemical, Thermal and Other Processes*. John Wiley and Sons Ltd.

Pizzi A and Mittal KL. 2011. *Wood Adhesives*. CRC Press.

Rowell RM. 2013. *Handbook of Wood Chemistry and Wood Composites*. 2nd Ed. CRC Press.

USDA. 1999. *Wood Handbook - Wood as an Engineered Material*. US Department of Agriculture, Forest Service. Forest Products Laboratory, Madison.

FPU 625 APPLICATION OF TRADITIONAL KNOWLEDGE 2+0

Theory

UNIT I

Traditional remedies for treating specific diseases like cardiovascular disease, mental disorders, rheumatic arthritis, diabetes, cough and asthma, fatigue, liver diseases, kidney and bladder stones, wounds stomach disorders etc. Traditional therapies *vis-a-vis* modern therapies.

UNIT II

Scientific validation of traditional systems of medicines/ remedies - case studies. Important herbs used in traditional medicines. Integration of herbal remedies with allopathic system of medicine. Allopathic drugs based on medicines herbs.

UNIT III

National and international research and other institutions involved in scientific validation of traditional knowledge eg. CDRI, CIMAP, RRL's, CCRAS, WHO etc., their role and major achievements.

UNIT IV

Composition of major herbal formulations e.g. Chavanprash, Vasavaleha, Arjunarishta, Pachakchurna etc. Major herbal pharmaceutical companies and their products like Dabur, Zandhu, Baidyanath, Himalayan Drug Company, Charak Pharmaceuticals etc. Role of local health traditions in primary health care.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Johnson CB and Franz C. 2005. *Breeding Research on Aromatic and Medicinal Plants*. International Book Distr.

Sharma R. 2004. *Agrotechniques of Medicinal Plants*. Daya Publ.

FPU 626 PROCESSING TECHNOLOGY OF MEDICINAL & AROMATIC PLANTS

2+1

Objective

To develop understanding of students about nutritional and post harvest aspects of medicinal and aromatic plants.

Theory

UNIT I

Identification of maturity indices and harvesting period based on active content. Harvesting method of underground parts, leaves, stem, bark, fruits, flowers etc.

UNIT II

Processing of harvested crops of medicinal and aromatic plants. Storage and value addition. Deterioration/ degradation of active principles during storage and their control.

UNIT III

Isolation of major bioactive compounds from medicinal plants, preparation of active content enriched extracts.

UNIT IV

Advances in extraction of essential oil.

Practical

Harvesting, drying, garbling, grading and packaging of medicinal and aromatic plants. Assessment of deterioration of active principles during storage and their control. Preparation of active content enriched extracts of important medicinal plants.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta AK and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants*.

Mann J 1994. *Chemical Aspects of Biosynthesis*. Oxford Chemistry Primers.

Sharma R. 2004. *Agrotechniques of Medicinal Plants*. Daya Publ.

FPU 627:VALUE ADDITIONS AND MARKETING OF MEDICINAL & AROMATIC PLANTS 2+1

Theory

UNIT I

Value addition for higher economic returns. Concepts and procedures. Preparation of powders, aqueous and alcoholic extracts, essences etc. Preparation of tablets, mixtures, balms, ointments, etc. Bulk storage and packaging of medicinal and aromatic plants.

UNIT II

Basic and advanced concepts of trade and marketing, marketing under disorganized and organized sector. Village and regional markets, state, national and international market of herbs and herbal products. Internet marketing practices for latest market value and other pattern of fluctuations for high value medicinal and aromatic plants/plant parts and products. Concept of e-market and quality standards.

Practical

Visit to nearby pharmaceutical concern for understanding value addition processes. Visit to local market and data collection on sale and sale procedure - organized and unorganized. Internet surfing for latest market value of high value of medicinal and aromatic plants.

Suggested Readings

Alikhan I and Khanum A. 2008. *Role of Biotechnology in Medicinal and Aromatic Plants*. UKAZ Publishers.

Chadha KL and Gupta R. 2006. *Advances in Horticulture*. Vol. XI. Medicinal and aromatic plants. Malhotra Publ. House.

Gupta K and Sharma M. 2008. *Reviews on Indian Medicinal Plants*. ICMR.

Gupta AK, Tandon N and Sharma M. 2008. *Quality Standards of Indian Medicinal Plants*.

Mann J 1994. *Chemical Aspects of Biosynthesis*. Oxford Chemistry Primers.

Sharma R. 2004. *Agrotechniques of Medicinal Plants*. Daya Publ.

Semester wise distribution of Supporting and Common courses of M.Sc. and Ph.D. Programmes

Supporting courses

Code	Course Title	Credit Hours
	Semester-I	
FOR-511*	General Statistical Methods and Computer	2+1

	Applications	
STAT 511	Experimental Designs	2+1
STAT 512	Statistical Methods for Applied Sciences	3+1
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
FOR-611**	Research Methodology in Forestry	2+1
	Semester-II	
BIOCHEM 521	Basic Biochemistry	3+1
BIOCHEM 522	Techniques in Biochemistry	2+2
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis using Statistical Packages	2+1
MCA 502	Computer Organization and Architecture	2+0
	Semester-III	
STAT 512	Basic Sampling Techniques	2+1
MCA 501	Computers Fundamental and Programming	2+1
MCA 512	Information Technology in Agriculture	1+1

*Compulsory of M.Sc. Forestry ** Compulsory for Ph.D. Forestry

Common Courses for M.Sc. Programme

Code	Course Title	Credit Hours
	Semester-I	
PGS-501	Library and Information services	0+1
	Semester-II	
PGS 502	Technical Writing and Communication Skills	0+1
PGS-504	Basic Concepts in Laboratory Techniques	0+1
	Semester-III	
PGS 503	Intellectual Property and its Management in Agriculture	1+0
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

Syllabus of supporting and common courses

FOR-511 General statistical methods and computer 2+1

Theory

UNIT I - Need for statistics in forestry experimentation and planning – population and sample. Correlation and regression: correlation coefficient/coefficient of determination, simple regression analysis; examples of multiple regressions. Examples of linear regression and its fitting by least square method.

UNIT II - Normal distribution and its application in forestry - properties of normal distribution. Confidence limits. Expected value of mean and standard error.

UNIT III - Tests of significance - Test for means in one sample and two sample cases (Z and t tests). Z-test for proportion, Chi-square test of variance in one sample case. F-test of variance in two

sample cases. Test of equality of K - means (one way and two way classification). Probability, basic laws of probability.

UNIT IV - Test of significance: Hypothesis, null and Alternative hypothesis, type-I and type-II error, Level of significance, Critical region, one and two tailed tests, Procedure for testing of hypotheses.

UNIT V - Need for sampling in forestry. Complete enumeration Vs partial enumeration. Principal steps in sample surveys, population, sampling unit, size of sample, (sample intensity) bias, accuracy and precision. Sampling variation and estimation of sampling error. Determination of sample size for a given level. Classified sampling design used in forest surveys. Simple random sampling - stratified random sampling. Systematic sampling - Point sampling.

UNIT VI - Basic principles of design of experiments, Uniformity trials and their uses, Fair field Smiths Variance Law and optimum size and shape of plots. Design and analysis of C.R.D. R.B.D. and L.S.D. with one observation per cell. Factorial experiments: Symmetrical and Asymmetrical factorial experiments, 2^n factorial experiments, Yates method and general method of analysis of AxB and AxBxC factorial experiments. Layout and analysis of Split and Strip plot design. Missing plot technique in R.B.D. and L.S.D. with one observation missing.

UNIT VII - Transformations: Square root, Logarithmic and Angular transformation.

UNIT VIII - Introduction to computer, MS Office, Statistical Application packages like MS-Excel, SPSS, R-software

Practical

Laying out of designs in the field. Analysis of 2^2 and 2^3 experiments in R.B.D., Analysis of AxB factorial experiments. Analysis of AxBxC factorial experiments, Missing plot analysis in case of R.B.D. with one observation missing, Missing plot analysis in case of L.S.D. with one observation missing. Analysis of Split plot and Strip plot design, Analysis of Covariance in case of R.B.D. Use of transformations. Analysis of results of the above design, Application of Statistical Packages like MS-Excel, SPSS, R-software with real forestry data

Suggested readings

V.G. Panse and P.V. Sukhatme (1985). Statistical Methods for Agricultural Workers. ICAR, New Delhi.

S.C. Gupta and V.K. Kapoor (2014). Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi.

Sukthame and C. Ashok (1984). Sampling Theories and Surveys with Application. ICAR, New Delhi, 3rd ed.

G.N. Rao (1983). Statistics for Agricultural Science. Oxford and IBH, New Delhi.

Das, M.N. and Giri. N.C. (1986). Design and analysis of Experiments. New Age International Publishers.

Kingra, H. S., Singh, G. (1993). Computer Basics for forestry, International Book Distributors, Dehradun.

Rajaraman, V and Adabala, N. (2015). *Fundamentals of Computers*, Pearson Education, New Delhi.

STAT-511

Experimental Designs

2+1

Theory

Unit I - Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II -Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III-Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV-Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design,

alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

VI. Practical

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

VII. Suggested Reading

- Cochran WG and Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- Dean AM and Voss D. 1999. *Design and Analysis of Experiments*. Springer.
- Montgomery DC. 2012. *Design and Analysis of Experiments*, 8th Ed. John Wiley.
- Federer WT. 1985. *Experimental Designs*. MacMillan.
- Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.
- Nigam AK and Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.

- Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.
- www.drs.icar.gov.in.

Statistical Sciences: Agricultural Statistics

STAT-512

Basic Sampling Techniques

2+1

Theory

Unit I-Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II-Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III-Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV-Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

VI. Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

VII. Suggested Reading

- Cochran WG. 1977. *Sampling Techniques*. John Wiley.
- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication

V. Theory

Unit I-Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

Unit II-Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

Unit III-Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

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

VI. Practical

- Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses;
- Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection;
- Handling of correlated errors, multi collinearity;
- Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

VII. Suggested Reading

- Kleinbaum DG, Kupper LL, Nizam A. 2007. *Applied Regression Analysis and Other Multivariable Methods* (Duxbury Applied) 4th Ed.
- Draper NR and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.
- Koutsoyiannis A. 1978. *Theory of Econometrics*. MacMillan.
- Kutner MH, Nachtsheim CJ and Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

V. Theory

Unit I-Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit II-Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.

Unit III-Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

Unit IV-Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

Unit V-Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

VI. Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample t -test, two sample t -test, paired t -test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components;
- Linear regression, Multiple regression, Regression plots;
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

VII. Suggested Reading

- Anderson C.W. and Loynes R.M. 1987. *The Teaching of Practical Statistics*. John Wiley.
- Atkinson A.C. 1985. *Plots Transformations and Regression*. Oxford University Press.
- Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmont, California.
- Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
- Cleveland W.S. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
- Erickson B.H. and Nosanchuk T.A. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.

- Snell E.J. and Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman and Hall.
- Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
- Velleman PF and Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
- Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
- Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.
- Wetherill GB. 1986. *Regression Analysis with Applications*. Chapman & Hall.
- Cleveland WS. 1994. *The Elements of Graphing Data*, 2nd Ed., Chapman & Hall
- <http://freestatistics.altervista.org/en/learning.php>. <http://freestatistics.altervista.org/en/stat.php>.
- http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- <http://www.stat.sc.edu/~grego/courses/stat706/>.
- www.drs.icar.gov.in.

BIOCHEM 501 Basic Biochemistry 3+1

Theory

Block 1: Introduction to Biochemistry

Unit 1: Scope and importance of biochemistry (1 Lecture) Biochemistry as modern science and its various divisions, Scope and importance of biochemistry in agriculture and allied sciences.

Unit 2: Foundation of life (2 Lectures) Fundamental principles governing life, supramolecular structures, significance of weak non covalent interactions in biology

Unit 3: Water (3 Lectures) Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship.

Unit 4: Physical techniques for structure determination (2 Lectures) General introduction to physical techniques for determination of structure of biopolymers.

Block 2: Structure And Function of Biomolecules

Unit 1: Biomolecules (10 Lectures) Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Unit 2: Immunoglobulins and PR proteins (2 Lectures) Structure, formation and different forms of immunoglobulins, PR proteins and their classification.

Unit 3: Plant secondary metabolites (3 Lectures) Structure, classification and function of plant secondary metabolites.

Block 3: Metabolism – The Basics

Unit 1: Molecules aiding metabolism (2 Lectures) Structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones: animal and plants.

Unit 2: Thermodynamics –principles and energetic of life (2 Lectures) Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Block 4: Catabolism and its Regulation

Unit 1: Catabolism of energy molecules (5 Lectures) Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation.

Unit 2: ATP formation (3 Lectures) Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic theory and proton motive force

Block 5: Fundamentals of Molecular Biology and Genetic Engineering

Unit 1: Molecular biology processes (4 Lectures) Overview of replication, transcription and translation.

Unit 2: Recombinant DNA technology (3 Lectures) Restriction enzymes, DNA cloning, applications of cloning, transgenics.

Practicals

- Preparation of standard and buffer solutions
- Detection of carbohydrates, amino acids and proteins
- Extraction and estimation of sugars
- Extraction and estimation of amino acids
- Extraction and estimation of proteins Basic Sciences: Biochemistry 457
- Estimation of acid value of fat/oil
- Estimation of peroxide value of fat/oil
- Estimation of saponification value in fats and oils
- Fatty acid composition in fat/oil by GC
- Estimation of DNA and RNA by spectroscopic methods

- Estimation of Ascorbic acid
- Separation of biomolecules by TLC and Paper chromatography
- Estimation of alpha amylase activity
- Qualitative tests for secondary plant metabolites.

Suggested Reading

- Nelson DL and Cox MM. 2017. Lehninger Principles of Biochemistry. 7th edition. W. H. Freeman & Co Ltd
- Satyanarayana U and Chakrapani U. 2017. Biochemistry. 5th edition, Elsevier
- Moran LA, Horton HR, Scrimgeour KG and Perry MD. 2012. Principles of Biochemistry. 5th edition Pearson.
- Voet D and Voet JG. 2011. Biochemistry. 4th edition John Wiley.
- Pratt CW and Cornely K. 2014. Essential Biochemistry. 3rd Edition. Wiley
- Moorthy K. 2007. Fundamentals of Biochemical Calculations. 2nd edition. CRC Press
- Conn EE, Stumpf PK, Bruening G and Doi RH. 2006. Outlines of Biochemistry. 5th edition. Wiley

BIOCHEM 505 Techniques in Biochemistry 2+2

Theory

Block 1: Separation Techniques

Principles and applications of separation techniques.

Unit 1: Chromatography techniques (4 Lectures)

Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity, column & HPTLC, GC, HPLC and FPLC

Unit 2: Electrophoretic technique (2 Lectures)

General principles, paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

Unit 3: Hydrodynamic methods (2 Lectures)

Hydrodynamic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles.

Unit 4: Centrifugation (2 Lectures)

Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation.

Block 2: Spectroscopic Techniques

Unit 1: Spectrophotometry (3 Lectures)

Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

Unit 2: Mass spectroscopy (3 Lectures)

MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry in biochemistry.

Unit 3: Atomic absorption spectrophotometry (2 Lectures)

Principle, function and instrumentation of atomic absorption spectrophotometry.

Block 3. Microscopy

Unit 1: Microscopic techniques (2 Lectures)

Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit 1: Tracer technique (2 Lectures)

Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α , β and γ emitters, scintillation counters, J-ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Unit 2: Imaging techniques (2 Lectures)

Principles and applications of phosphor imager, MRI and CT scan.

Unit 3: Immunochemical technique (2 Lectures)

Production of antibodies, immunoprecipitation, immunoblotting, immunoassays, RIA and ELISA

Unit 4: Other techniques (2 Lectures)

Cryopreservation, polymerase chain reaction (PCR), FACS.

Practicals

- Expression of concentration in terms of dilution, molarity, normality, percent expression
- pH measurement and buffer preparation
- Determination of absorption maxima of biomolecules

- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography
- Separation and analysis of fatty acids/lipids by GC
- Separation/estimation of biomolecules through HPLC and FPLC
- Separation of proteins using ion exchange, gel filtration and affinity chromatography
- Electrophoretic separation of proteins and nucleic acids
- Centrifugation- differential and density gradient
- (NH₄)₂SO₄ precipitation and dialysis
- Use of radioisotopes in metabolic studies
- PCR
- ELISA
- Western blotting/ Dot blotting

Suggested Reading

- Boyer R. 2011. Biochemistry Laboratory: Modern Theory and Techniques 2nd Edition. Pearson
- Hofmann A and Clokie S. 2010. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press.
- Sawhney SK and Singh R. 2000. Introductory Practical Biochemistry. 2nd Ed. Narosa
- Katoch R. 2011. Analytical Techniques in Biochemistry and Molecular Biology. Springer
- Boyer R. 2009. Modern Experimental Biochemistry. Fifth impression. Parson
- Lottspeich F and Engels JW. (Eds). 2018. Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH
- Wilson K and Walker J. 2010. Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press

PGS-501 LIBRARY AND INFORMATION SERVICES (0+1)

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of

CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

PGS-502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Practical (Technical Writing)

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

Suggested Readings

Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*.

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995.

Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.

Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

Richard WS. 1969. *Technical Writing*.

Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

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

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPs Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations

for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

PGS-504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.

Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

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

Theory

UNIT I-History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

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

UNIT III-Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS and Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.

Punia MS. *Manual on International Research and Research Ethics*. CCS Haryana Agricultural University, Hisar.

Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.

Singh K. 1998. *Rural Development - Principles, Policies and Management*. Sage Publ.

Faculty of Agriculture

Nomenclature of Degree Programme:

S. No.	Discipline/Departments	Nomenclature of Degree Programme		Hindi Name
		M.Sc.	Ph.D.	
1	Genetics and Plant Breeding	M.Sc. (Agri.) Genetics and Plant Breeding	Ph.D. Genetics and Plant Breeding	पादप प्रजनन एवं आनुवंशिकी

2	Plant Pathology	M.Sc. (Agri.) Plant Pathology	Ph.D. Plant Pathology	पादप रोग विज्ञान
3	Agronomy	M.Sc. (Agri.) Agronomy	Ph.D. Agronomy	शस्य विज्ञान
4	Soil Science	M.Sc. (Agri.) Soil Science	Ph.D. Soil Science	मृदा विज्ञान
5	Agricultural Extension Education	M.Sc. (Agri.) Agricultural Extension Education	Ph.D. Agricultural Extension Education	कृषि प्रसार शिक्षा
6	Entomology	M.Sc. (Agri.) Entomology	Ph.D. Entomology	कीट विज्ञान
7	Nematology	M.Sc. (Agri.) Nematology	Ph.D. Nematology	सूत्रकृमि विज्ञान
8	Agricultural Economics	M.Sc. (Agri.) Agricultural Economics	Ph.D. Agricultural Economics	कृषि अर्थशास्त्र

M.Sc. (Agri.) Agronomy

S. No.	Proposed Course Code	Course Title	Credit Hrs.
1.	AGRON 511*	Modern Concepts in Crop Production	3(3+0)
2.	AGRON 512*	Principles and Practices of Water Management	3(2+1)
3.	AGRON 513	Principles and Practices of Organic Farming	3(2+1)

4.	AGRON 514	Conservation Agriculture	2(1+1)
5.	AGRON 521*	Principles and Practices of Weed Management	3(2+1)
6.	AGRON 522*	Principles and Practices of Soil Fertility and Nutrient Management	3(2+1)
7.	AGRON 523	Dryland Farming and Watershed Management	3(2+1)
8.	AGRON 524	Cropping Systems and Sustainable Agriculture	2(2+0)
9.	AGRON 525	Agronomy of Fodder and Forage Crops	3(2+1)
10.	AGRON 531	Agronomy of Major Cereals and Pulses	3(2+1)
11.	AGRON 532	Agronomy of Oilseeds, Fibre and Sugar Crops	3(2+1)
12.	AGRON 533	Agrostology and Agro-Forestry	3(2+1)
13.	AGRON 534	Agronomy of Medicinal, Aromatic and Under Utilized Crops	3(2+1)
14.	AGRON 541	Master's Seminar	1
15.	AGRON 543	Master's Research	30

Syllabus of M.Sc. (Agri.) Agronomy

AGRON-501 ; Modern Concepts in Crop Production 3+0

THEORY

Unit I

Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

Unit IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

Unit V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture. Modern crop

production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

RESOURCES

- Balasubramaniyan P and Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.
- Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7thEd. Prentice Hall.
- Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.
- Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Alvin PT and kozlowski TT (ed.). 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.
- Gardner PP, Pearce GR and Mitchell RL. 1985. *Physiology of Crop Plants*. Scientific Pub. Jodhpur.
- Lal R. 1989. *Conservation tillage for sustainable agriculture: Tropics versus Temperate Environments*. *Advances in Agronomy* 42: 85-197.
- Wilsie CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.

AGRON 502 : Principle and Practices of Soil Fertility and Nutrient Management 2+1

THEORY

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermicompost and residue wastes in crops.

PRACTICAL

- Determination of soil pH and soil EC

- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

RESOURCES

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7th Ed. Prentice Hall.
- Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*
- Yawalkar KS, Agrawal JP and Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.

AGRON-503 (AGRON 521) Principles and Practices of Weed Management 2+1

THEORY

Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and classification management; weed indices, weed shift in different eco-systems

Unit II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allelochemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combination and rotation.

Unit IV

Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit V

Integrated weed management; recent development in weed management- robotics, use of drones and aeroplanes, organic etc., cost: benefit analysis of weed management.

PRACTICAL

- Identification of important weeds of different crops, Preparation of a weed herbarium, weed survey in crops and cropping systems, Crop-weed competition studies, weed indices calculation and interpretation with data, Preparation of spray solutions of herbicides for high

and low-volume sprayers, Use of various types of spray pumps and nozzles and calculation of swath width, Economics of weed control, Herbicide resistance analysis in plant and soil,

- Bioassay of herbicide resistance residues,
- Calculation of herbicidal herbicide requirement

RESOURCES

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.
- Chauhan B and Mahajan G. 2014. *Recent Advances in Weed Management*. Springer.
- Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi).
- Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. *Weed Management: Principles and Practices*, 2nd Ed.
- Jugulan, Mithila (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley
- Powles SB and Shaner DL. 2001. *Herbicide Resistance and World Grains*, CRC Press.
- Walia US. 2006. *Weed Management*, Kalyani.
- Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture*, B. D. Sci. Pub.

AGRON 504 Principles and Practices of Water Management 2+1

THEORY

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-water- plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and losses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

Unit IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII

Hydroponics

Unit IX

Water management of crops under climate change scenario.

PRACTICAL

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head method
- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity
- Estimation of upward flux of water using tensiometer and from depth ground water table
- Determination of irrigation requirement of crops (calculations)
- Determination of effective rainfall (calculations)
- Determination of ET of crops by soil moisture depletion method
- Determination of water requirements of crops
- Measurement of irrigation water by volume and velocity-area method
- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
- Determination of infiltration rate by double ring infiltrometer

RESOURCES

- Majumdar DK. 2014. *Irrigation Water Management: Principles and Practice*. PHL Learning private publishers
- Mukund Joshi. 2013. *A Text Book of Irrigation and Water Management Hardcover*, Kalyani publishers
- Lenka D. 1999. *Irrigation and Drainage*. Kalyani.
- Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
- Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.
- Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
- Prihar SS and Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Singh Pratap and Maliwal PL. 2005. *Technologies for Food Security and*

AGRON-505 :Conservation Agriculture

1+1

THEORY

Unit I

Conventional and conservation agriculture systems, sustainability concerns, conservation agriculture: Historical background and present concept, global experiences, present status in India.

Unit II

Nutrient management in CA, water management, weed management, energy use, insect-pest and disease management, farm machinery, crop residue management, cover crop management.

Unit III

Climate change mitigation and CA, C-sequestration, soil health management, soil microbes and CA.

Unit IV

CA in agroforestry systems, rainfed / dryland regions

Unit V

Economic considerations in CA, adoption and constraints, CA: The future of agriculture

PRACTICALS

- Study of long-term experiments on CA,
- Evaluation of soil health parameters,
- Estimation of C-sequestration,
- Machinery calibration for sowing different crops, weed seedbank estimation under CA, energy requirements, economic analysis of CA.

RESOURCES

- Arakeri HR and Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.
- Bisht JK, Meena VS, Mishra PK and Pattanayak A. 2016. Conservation Agriculture-An approach to combat climate change in Indian Himalaya. Publisher: Springer Nature. Doi: 10/1007/978-981-10-2558-7.
- Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.
- FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas*. *Soils Bull.*, Paper 57.
- Gracia-Torres L, Benites J, Martinez-Vilela A and Holgado-Cabera A. 2003. Conservation Agriculture- Environment Farmers experiences, innovations Socio-economic policy.

- Muhammad F and Kamdambot HMS. 2014. Conservation Agriculture. Publisher: Springer Cham Heidelberg, New York Dordrecht London. Doi: 10.1007/978-3-319-11620-4.
- Yellamanda Reddy T and Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

AGRON-506 :Agronomy of Major Cereals and Pulses 2+0

THEORY

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of:

Unit I:

Rabi cereals.

Unit II:

Kharif cereals.

Unit III:

Rabi pulses.

Unit IV:

Kharif pulses.

Unit VI

Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ratio, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in selected crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Resources

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Hunsigi G and Krishna KR. 1998. *Science of Field Crop Production*. Oxford & IBH.
- Jeswani LM and Baldev B. 1997. *Advances in Pulse Production Technology*. ICAR.
- Khare D and Bhale MS. 2000. *Seed Technology*. Scientific Publ.
- Kumar Ranjeet and Singh NP. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.
- Pal M, Deka J and Rai RK. 1996. *Fundamentals of Cereal Crop Production*. Tata McGraw Hill.
- Prasad Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.
- Singh C, Singh P and Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
- Singh SS. 1998. *Crop Management*. Kalyani.
- Yadav DS. 1992. *Pulse Crops*. Kalyani.

AGRON-507 :Agronomy of Oilseed, Fibre and Sugar Crops 2+1

THEORY

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing of the produce for maximum production of:

Unit I

Rabi oilseeds – Rapeseed and mustard, Linseed and Niger

Unit II

Kharif oilseeds - Groundnut, Sesame, Castor, Sunflower, Soybean and Safflower

Unit III

Fiber crops - Cotton, Jute, Ramie and Mesta.

Unit IV

Sugar crops – Sugar-beet and Sugarcane.

PRACTICAL

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield

- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production.

RESOURCES

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Das PC. 1997. *Oilseed Crops of India*. Kalyani.
- Lakshmikantam N. 1983. *Technology in Sugarcane Growing*. 2nd Ed. Oxford & IBH.
- Prasad Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.
- Singh C, Singh P & Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
- Singh SS. 1998. *Crop Management*. Kalyani.

AGRON-508 :Agronomy of Medicinal, Aromatic and Under-Utilized Crops 2+1

THEORY

Unit I

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

Unit II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, *Stevia*, Safed Musli, Kalmegh, Asaphoetida, *Nuxvomica*, Rosadle, etc).

Unit III

Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium).

Unit IV

Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Clusterbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

Unit V

Post-harvest handling –drawing, processing, grading, packing and storage, value addition and quality standards in herbal products.

PRACTICAL

- Identification of crops based on morphological and seed characteristics
- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.

RESOURCES

- Chadha KL and Gupta R. 1995. *Advances in Horticulture*. Vol. II. *Medicinal and Aromatic Plants*. Malhotra Publ.
- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Handa SS. 1984. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.
- Hussain A. 1984. *Essential Oil Plants and their Cultivation*. CIMAP, Lucknow.
- Hussain A. 1993. *Medicinal Plants and their Cultivation*. CIMAP, Lucknow.
- ICAR 2006. *Hand Book of Agriculture*. ICAR, New Delhi.
- Kumar N, Khader Md. Abdul, Rangaswami JBM & Irulappan 1997. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford & IBH.
- Prajapati ND, Purohit SS, Sharma AK and Kumar T. 2003. *A Hand Book of Medicinal Plants: A Complete Source Book*. Agrobios.
- Sharma R. 2004. *Agro-Techniques of Medicinal Plants*. Daya Publ. House.

AGRON-509 :Agronomy of Fodder and Forage Crops 2+1

THEORY

Unit I

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum, maize, *bajra*, *guar*, cowpea, oats, barley, berseem, *senji*, lucerne, etc.

Unit II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses, lime, Napier grass, *Panicum*, *Lasiurus*, *Cenchrus*, etc.

Unit III

Year-round fodder production and management, preservation and utilization of forage and pasture crops.

Unit IV

Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor-quality fodder. Fodder production through hydroponics. Azolla cultivation.

Unit V

Economics of forage cultivation uses and seed production techniques of important fodder crops.

PRACTICAL

- Practical training of farm operations in raising fodder crops;
- Canopy measurement, yield, Leaf: Stem ratio and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose and IVDMD, etc. of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation.

RESOURCES

- Chatterjee BN. 1989. *Forage Crop Production - Principles and Practices*. Oxford & IBH.

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Narayanan TR and Dabadghao PM. 1972. *Forage Crops of India*. ICAR.
- Singh P and Srivastava AK. 1990. *Forage Production Technology*. IGFRI, Jhansi.
- Singh C, Singh P and Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
- Tejawani KG. 1994. *Agroforestry in India*. Oxford & IBH.

AGRON-510 :Agrostology and Agro-forestry

2+1

THEORY

Unit I

Agrostology: definition and importance; principles of grassland ecology: grassland ecology – community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

Unit II

Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

Unit III

Agroforestry: definition and importance; agroforestry systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.

Unit IV

Crop production technology in agro-forestry and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro- forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

PRACTICAL

- Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination of farm vegetation
- Methods of propagation/ planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvipastoral systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry research stations

RESOURCES

- Chatterjee BN and Das PK. 1989. *Forage Crop Production. Principles and Practices*.

Oxford & IBH.

- Dabadghao PM and Shankaranarayan KA. 1973. *The Grass Cover in India*. ICAR.
- Dwivedi AP. 1992. *Agroforestry- Principles and Practices*. Oxford & IBH.
- Indian Society of Agronomy. 1989. *Agroforestry System in India. Research and Development*, New Delhi.
- Narayan TR and Dabadghao PM. 1972. *Forage Crop of India*. ICAR, New Delhi.

AGRON-511: Cropping Systems and Sustainable Agriculture 2+0

THEORY

Unit I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

Unit II

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

Unit III

Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low-cost technologies; research need on sustainable agriculture.

Unit IV

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

Unit V

Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Unit VI

Artificial Intelligence- Concept and application.

RESOURCES

- Panda SC. 2017. *Cropping Systems and Sustainable Agriculture*. Agrobios (India)
- Panda SC. 2018. *Cropping and Farming Systems*. Agrobios.
- Palaniappan SP and Sivaraman K. 1996. *Cropping Systems in the Tropics; Principles and Management*. New Age.
- Panda SC. 2003. *Cropping and Farming Systems*. Agrobios.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ. Co.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1997. *Soil Fertility and Fertilizers*. Prentice Hall.

AGRON-512 : Dryland Farming and Watershed Management 2+1

THEORY

Unit I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

Unit II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

Unit III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

Unit IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

Unit V

Concept of watershed resource management, problems, approach and components.

PRACTICAL

- Method of Seed Priming
- Determination of moisture content of germination of important dryland crops
- Determination of Relative Water Content and Saturation Deficit of Leaf
- Moisture stress effects and recovery behaviour of important crops
- Estimation of Potential ET by Thornthwaite method
- Estimation of Reference ET by Penman Monteith Method
- Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)
- Classification of climate by Koppen Method
- Estimation of water balance by Thornthwaite method
- Estimation of water balance by FAO method
- Assessment of drought
- Estimation of length of growing period
- Estimation of probability of rain and crop planning for different drought condition
- Spray of anti-transpirants and their effect on crops
- Water use efficiency

- Visit to dryland research stations and watershed projects

RESOURCES

- Reddy TY. 2018. *Dryland Agriculture Principles and Practices*, Kalyani publishers
- Das NR. 2007. *Tillage and Crop Production*. Scientific Publ.
- Dhopte AM. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.
- Dhruv Narayan VV. 2002. *Soil and Water Conservation Research in India*. ICAR.
- Gupta US. (Ed.). 1995. *Production and Improvements of Crops for Drylands*. Oxford & IBH.
- Katyal JC and Farrington J. 1995. *Research for Rainfed Farming*. CRIDA.
- Rao SC and Ryan J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publ.
- Singh P and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ. Company.
- Singh RP. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.
- Singh RP. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.
- Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publ.
- Venkateshwarlu J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

AGRON-513 : Principles and Practices of Organic Farming 2+1

THEORY

Unit I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organics and farming standards; organic farming and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

Unit II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, bio-fertilizers and biogas technology.

Unit III

Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

Unit IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides.

Unit V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

PRACTICAL

- Method of making compost by aerobic method
- Method of making compost by anaerobic method
- Method of making vermicompost
- Identification and nursery raising of important agro-forestry trees and trees for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to a biogas plant
- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

RESOURCES

- Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.
- Gaur AC. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document, FAO.
- Joshi M. 2016. *New Vistas of Organic Farming*. Scientific Publishers
- Lampin N. 1990. *Organic Farming*. Press Books, Ipswich, UK.
- Palaniappan SP and Anandurai K. 1999. *Organic Farming – Theory and Practice*. Scientific Publ.
- Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, ParisaraprajnaParishtana, Bangalore.
- Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.
- Sharma A. 2002. *Hand Book of Organic Farming*. Agrobios.
- Singh SP. (Ed.). 1994. *Technology for Production of Natural Enemies*. PDBC, Bangalore.
- Subba Rao NS. 2002. *Soil Microbiology*. Oxford & IBH.
- Trivedi RN. 1993. *A Text Book of Environmental Sciences*, Anmol Publ.
- Veeresh GK, Shivashankar K and Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture*. Association for Promotion of Organic Farming, Bangalore.
- WHO. 1990. *Public Health Impact of Pesticides Used in Agriculture*. WHO.
- Woolmer PL and Swift MJ. 1994. *The Biological Management of Tropical Soil Fertility*. TSBF & Wiley.

Ph.D. Agronomy

S. N.	Course Code as per BSMA	Course Code	Course Title	Credit Hrs.
1.	AGRON 601*	AGRON 611*	Current trends in Agronomy	3(3+0)
2.	AGRON 602	AGRON 612	Recent trends in crop growth and productivity	3(2+1)
3.	AGRON 605	AGRON 613	Integrated farming systems for sustainable agriculture	2(2+0)
4.	AGRON 606	AGRON 614	Soil conservation and watershed	3(2+1)

			management	
5.	AGRON 603	AGRON 621	Irrigation management	3(2+1)
6.	AGRON 604	AGRON 622	Recent trends in weed management	2(2+0)
7.	AGRON 607	AGRON 623	Stress crop production	3(2+1)
8.	AGRON 608*	AGRON 624*	Research and publication ethics	2(2+0)
9.	AGRON 691	AGRON 641	Doctoral Seminar	1(1+0)
10.	AGRON 692	AGRON 642	Doctoral Seminar	1(1+0)
11.	-	AGRON 643	Comprehensive	NC (S/NS)
12.	AGRON 699	AGRON 644	Doctoral Research	75

AGRON 601: Current Trends in Agronomy

3+0

THEORY

Unit I

Agro-physiological basis of variation in yield, recent advances in soilplant-water relationship.

Unit II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming.

Unit III

Crop residue management in multiple cropping systems; latest developments in plant management; Mechanization in crop production: modern agricultural precision tools and technologies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

Unit IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

Unit V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues.

RESOURCES

- Agarwal RL. 1995. *Seed Technology*. Oxford & IBH.
- Dahiya BS and Rai KN. 1997. *Seed Technology*. Kalyani.
- Govardhan V. 2000. *Remote Sensing and Water Management in Command Areas: Agroecological Prospectives*. IBDC.
- ICAR. 2006. *Hand Book of Agriculture*. ICAR.
- Narasaiah ML. 2004. *World Trade Organization and Agriculture*. Sonali Publ.
- Palaniappan SP and Annadurai K. 2006. *Organic Farming - Theory and Practice*. Scientific Publ.

- Sen S and Ghosh N. 1999. *Seed Science and Technology*. Kalyani.
- Tarafdar JC, Tripathi KP and Kumar M. 2007. *Organic Agriculture* Scientific Publ.
- Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. *A Text Book of Seed Technology*. Kalyani Publication.
- Reddy SR and Prabhakara G. 2015. *Dryland Agriculture*. Kalyani Publishers.
- Gururajan B, Balasubhramanian R and Swaminath V. 2013. *Recent Strategies on Crop Production*. Kalyani Publishers.
- Venkateswarlu B and Shanker Arun K. 2009. *Climate change and agriculture:.*

AGRON 602 (AGRON 612) Recent Trends in Crop Growth and Productivity 2+1

THEORY

Unit I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

Unit II

Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

Unit III

Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

Unit IV

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

PRACTICAL

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth
- Computation of harvest index of various crops

- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, viz. LER, IER aggressivity competition index etc. in intercropping
- Senescence and abscission indices
- Analysis of productivity trend in un-irrigated areas
- Analysis of productivity trend in irrigated areas

RESOURCES

- Chopra VL and Paroda RS. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. Oxford & IBH.
- Delvin RM and Vitham FH. 1986. *Plant Physiology*. CBS Publ.
- Evans LT. 1975. *Crop Physiology*. Cambridge Univ. Press.
- Evans LT. 1996. *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press.
- Gupta US. (Ed.). 1995. *Production and Improvement of Crops for Drylands*. Oxford & IBH.
- Gupta US. 1988. *Progress in Crop Physiology*. Oxford & IBH.
- Kramer PJ and Boyer JS. 1995. *Water Relations of Plant and Soils*. Academic Press.
- Mukherjee S and Ghosh AK. 1996. *Plant Physiology*. Tata McGraw Hill.
- Narwal SS, Politycka B and Goswami CL. 2007. *Plant Physiology: Research Methods*. Scientific Pub.
- Tiaz L. and Zeiger E. 2006. *Plant Physiology*. Sinauer Associates, Inc

AGRON 605 :Integrated Farming Systems and Sustainable Agriculture 2+0

THEORY

Unit I

Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/irrigated condition in different land situation. farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

Unit II

Concept of sustainability in of Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources - identification and management.

Unit III

Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information. in different systems through research; eco-physiological

approaches to intercropping. Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; evaluation of IFS.

Unit IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. Formation of different Integrated Farming system Models; evaluation of different Integrated Farming system models. Recycling of organic waste in farming system, in IFS.

Unit V

New concepts and approaches of farming system and organic farming; value addition, waste recycling, quantification and mitigation of Green House gases; case studies/ success stories of different Integrated Farming systems. cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in Integrated farming system.

RESOURCES

- Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.
- Baishya A, Borah M, Das AK, Hazarika J, Gogoi B and Borah AS 2017. *Waste Recycling Through Integrated Farming systems. An Assam Agriculture Experience*. Omni Scriptum GmbH & Co. KG, Germany.
- Balasubramanian P and Palaniappan SP. 2006. *Principles and Practices of Agronomy*. Agrobios.
- Edens T. 1984. *Sustainable agriculture and integrated farming system*. Michigan State Univ. press.
- Jayanthi C. 2006. *Integrated Farming systems-A way to sustainable Agriculture*. Tamil Nadu Agricultural University, Coimbatore
- Joshi M and Parbhakarasetty TK. 2005. *Sustainability through Organic Farming*. Kalyani.
- Kolhapure A and Madhukar D. *A text book of farming system and sustainable agriculture*.
- Palaniappan SP and Anandurai K. 1999. *Organic Farming - Theory and Practice*. Scientific Publ.
- Panda SC. 2004. *Cropping systems and Farming Systems*. Agribios.
- Lampin N. 1990. *Organic Farming*. Farming Press Books.
- Ravisankar D and Jayanthi C. 2015. *Farming systems: concepts and approaches*. Agrobios,

AGRON 606 : Soil Conservation and Watershed Management 2+1

THEORY

Unit I

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

Unit II

Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

Unit III

Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

Unit IV

Land use capability classification, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout.

Unit V

Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

PRACTICAL

- Study of different types of erosion
- Determination of dispersion ratio
- Estimation of soil loss by Universal Soil Loss Equation
- Estimation of soil loss by wind erosion
- Measurement of runoff and soil loss
- Field studies of different soil conservation measures
- Laying out run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to watershed areas
- Visit to a soil conservation research centre, demonstration and training centre

RESOURCES

- Arakeri HR and Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.
- Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.
- FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas*. *Soils Bull.*, Paper 57.
- Frederick RT, Hobbs J, Arthur D and Roy L. 1999. *Soil and Water Conservation: Productivity and Environment Protection*. 3rd Ed. Prentice Hall.
- Gurmeh Singh, Venkataraman CG, Sastry B and Joshi P. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.
- Murthy VVN. 1995. *Land and Water Management Engineering*. Kalyani.
- Tripathi RP and Singh HP. 1993. *Soil Erosion and Conservation*. Wiley Eastern.
- Yellamanda Reddy T and Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

AGRON 603 : Irrigation Management

2+1

THEORY

Unit I

Global water resources; Water resources of India, irrigation projects during pre and post-independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit II

Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseuille's and Darcy's law, general equation of saturated and unsaturated flow of water in soil. Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

Unit III

Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

Unit IV

Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation.

Unit V

Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability.

Unit VI

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

Unit VII

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

Unit VIII

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Unit IX

Economic analysis of irrigation and crop planning for optimum use of irrigation water

Unit X

Crop water production function

PRACTICAL

- Determination of water infiltration characteristics and water holding capacity of soil profiles.
- Determination Moisture extraction pattern of crops
- Determination of water balance component of transplanted rice by drum culture technique
- Determination of consumptive use and water requirement of a given cropping pattern
- Determination of crop efficient of one important crop
- Planning, designing and installation of drip irrigation system

- Planning, designing and installation of sprinkler irrigation system
- Designing of drainage channel
- Measurement of irrigation efficiencies
- Determination of irrigation timing under different methods of irrigation
- Visit to irrigation command area

RESOURCES

- MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers
- FAO. 1984. *Irrigation Practice and Water Management*. Oxford & IBH.
- Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
- Mishra RR and Ahmad M. 1987. *Manual on Irrigation and Agronomy*. Oxford & IBH.
- Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.
- Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH

AGRON 604 : Recent Trends in Weed Management 2+0

THEORY

Unit I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion.

Unit II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

Unit III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Unit IV

Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

SUGGESTED READING

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.
- Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi)
- Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. *Weed Management: Principles and Practices*, 2nd Ed.
- Jugulan M, (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley
- Powles SB and Shaner DL. 2001. *Herbicide Resistance and World Grains*, CRC Press.
- Walia US. 2006. *Weed Management*, Kalyani.
- Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture*, B. D. Sci. Pub.

AGRON 607 : Stress Crop Production

2+1

Unit I

Stress and strain terminology; nature and stress injury and resistance; causes of stress.

Unit II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through, soil and crop manipulations.

Unit III

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

Unit IV

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

Unit V

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

Unit VI

Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

Unit VII

Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

Unit VIII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Measurement of Relative Water Content of leaf
- Measurement of electrolytic leakage
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions
- Studies on plant responses to excess water.

RESOURCES

- Baker FWG.1989. *Drought Resistance in Cereals*. Oxon, UK.
- Gupta US. (Ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.
- Kramer PJ.1983. *Water Relations of Plants*. Academic Press.
- Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.
- Mavi HS.1978. *Introduction to Agro-meteorology*. Oxford & IBH.
- Michael AM and Ojha TP.1981. *Principles of Agricultural Engineering*. Vol II. Jain Bros.
- Nilsen ET and Orcut DM. 1996. *Physiology of Plants under Stress – Abiotic Factors*. John Wiley & Sons.
- Singh K. 2000. *Plant Productivity under Environmental Stress*. Agribios.
- Singh KN and Singh RP. 1990. *Agronomic Research Towards Sustainable Agriculture*. Indian Society of Agronomy, New Delhi.
- Somani LL and Totawat KL. 1992. *Management of Salt-affected Soils and Waters*. Agrotech Publ.

- Virmani SM, Katyal JC, Eswaran H and Abrol IP. 1994. *Stressed Ecosystem and Sustainable Agriculture*. Oxford & IBH.

AGRON 608 : Research and Publication Ethics 0+2

THEORY

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Definition, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self-archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open-source software tools

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics

M.Sc. (Agri.) Agricultural Extension Education

Major Course				
S. No.	Course code as per BSMA	Proposed Course code	Course Title	Credit Hour
1.	EXT-501*	EXT – 511	Extension Landscape	2 (2+0)
2.	EXT-502*	EXT - 512*	Applied Behaviour Change	3 (2+1)
3.	EXT-504*	EXT - 513*	Research Methodology in Extension	3 (2+1)
4.	EXT-505*	EXT - 521*	Capacity Development	3 (2+1)
5.	EXT-506*	EXT - 522*	ICTs for Agricultural Extension and Advisory Services	3 (2+1)
6.	EXT-507*	EXT - 523	Evaluation and Impact Assessment	3 (2+1)
7.	EXT-503*	EXT - 531	Organizational Behaviour and Development	3 (2+1)
Minor Courses				
8.	EXT-509	EXT - 514	Enabling Innovation	2 (1+1)
9.	AEC- 506	AEC - 515	Agricultural Development and Policy Analysis	2 (2+0)
10.	EXT-508	EXT - 532	Managing Extension Organizations	3 (2+1)
11.	EXT-510	EXT - 533	Gender Mainstreaming	3 (2+1)
12.	AEC-507	AEC- 533	Agricultural Finance and Project Management	3 (2+1)
Supporting Courses				
13.	STAT-502	STAT- 511	Statistical Methods for Applied Sciences	4 (3+1)
14.	STAT/COMP	COMP- 521	Computer Applications for Agricultural Extension Research	3 (2+1)
15.	STAT-512	STAT- 522	Basic Sampling Techniques	3 (2+1)
16.	EXT.591	EXT - 541	Seminar	1
17.	-	EXT - 542	Research	30

EXT 501 : Extension Landscape 2+0

Unit I Challenges before Extension and Advisory Services (EAS)

Extension and Advisory Services (EAS)- Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals: Natural Resource Management- Supporting farmers to manage the declining/deteriorating water and soil for farming; Gender Mainstreaming- How extension can enhance access to new knowledge among women farmers; Nutrition- Role of extension in supporting communities with growing nutritious crop and eating healthy food; Linking farmers to markets- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems; Adaptation to climate changes-How extension can contribute to up-scaling Climate Smart Agriculture; Supporting family farms- strengthening the capacities of family farms; Migration-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills; Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; Urban and peri-urban farming- How to support and address issues associated with urban and peri-urban agriculture; Farmer distress, suicides- Supporting farmers in tackling farm distress

Unit II: New Functions and New Capacities

Beyond transfer of technology: Performing new functions to deal with new challenges; Organising producers into groups-dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets; Mediating conflicts and building consensus to strengthen collective decision making; Facilitating access to credit, inputs and services-including development of service providers; Influencing policies to promote new knowledge at a scale Networking and partnership development including convening multi-stakeholder platforms/ innovation platforms. New Capacities needed by extension and advisory services at different levels –at the individual (lower, middle management and senior management levels), organizational and enabling environment levels; –Core competencies at the individual level; Varied mechanisms for capacity development (beyond training).

Unit III: Pluralism in EAS

Pluralism in Extension Delivery: Role of private sector (input firms, agri-business companies, consultant firms and individual consultants)- Trends in the development of private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental Organizations (National/international)/ Civil Society Organizations (CSOs) in providing extension- Experiences from India and other countries; Producer Organizations- Role in strengthening demand and supply of extension services; their strength and weaknesses-experiences from different sectors; Role of Media and ICT advisory service providers; global experiences with use of media and ICTs in advisory services provision

Unit I: From the Linear Paradigm to Systems Paradigm

Diffusion of Innovations paradigm- strengths and limitations; multiple sources of innovation-farmer innovation, institutional innovation; farmer participation in technology generation and promotion; strength and limitations; Agricultural Knowledge and Information Systems (AKIS); strength and limitations; Agricultural Innovation Systems (AIS); Redefining Innovation- Role of Extension and Advisory Services in AIS-From information delivery to intermediation across multiple nodes; Role of brokering; Innovation Platforms, Innovation Management; Strength and weaknesses of AIS. Rethinking Communication in the Innovation Process – Network building, support social learning, dealing with dynamics of power and conflict.

Unit 2: Evolving Extension Approaches

Evolution and features of extension approaches: Transfer of technology approach; educational approach, farmer participatory eXtension approach, demand-driven extension, market led extension (value chain extension), extension for climate smart agriculture, gender sensitive extension, extension for entrepreneurship Extension systems in different regions: Asia-Pacific, Europe, Latin America, Australia, North America Networking for Strengthening EAS: GFRAS (Global Forum for Rural Advisory Services) and its regional networks.

Unit 1: Changes in Governance, Funding and Delivery

Reduction in public funding: public withdrawal from extension provision (partial/ full); Examples/Cases; Privatization: Public funding and private delivery; cost sharing and cost recovery; Examples/Cases; Decentralization of extension services; Examples/Cases; Lessons from eXtension reforms in different countries; Extension and Sustainable Development Goals (SDGs).

Unit 2: Challenges in Managing Pluralistic Extension Systems

Pluralism: Managing pluralism and Co-ordination of pluralistic extension provision; Public private partnerships in extension (including the role of local governments/panchayats and producer organisations); Examples, challenges in co-ordination; Achieving convergence in extension planning and delivery, Financing Extension: Mobilising resources for extension: public investments, donor support (grants/loans); Monitoring and Evaluation of Extension: Generating appropriate data for Assessment and Evaluation of pluralistic extension; Strengthening extension policy interface generating evidence on impact of extension and policy relevant communication.

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EXT 502 : Applied Behaviour Change

2+1

THEORY

Block 1: Foundations of Behaviour Change

Unit 1: Foundations of Human Behaviour

Human behaviour – Meaning, importance and factors influencing human behaviour; Biological bases of human behaviour – Nervous system, brain, endocrine system and genes; Individual variations – intelligence, ability and creativity– foundations and theories, personality and temperament - foundations, approaches, theories of personality, measuring personality (traits, locus of control, self-efficacy; Personal, social and moral development – meaning, concepts – self-concept, self-esteem and self-worth and theories. Motivation – foundations, approaches, theories, managing human needs and motivations; perceiving

others – impression, attitude, opinions; Emotions - foundations, types and functions, measuring emotional intelligence.

Block 2: Cognitive Processes And Learning

Unit 1: Cognitive Processes affecting Human Behaviour

Sensory organs and their role cognition; Cognitive processes – Attention, perception, remembering and forgetting, knowledge and expertise – foundations and theories; Principles and processes of perception; Consciousness – meaning, types, sleep and dreams; Learning and Memory – Memory - meaning, types and mechanisms of storage and retrieval of memories in the Human brain; Complex cognitive processes- Concept formation, Thinking, Problem solving and transfer – foundations, theories and approaches

Unit 2: Information Processing

Information processing – meaning, principles; Models of information processing - Waugh and Norman model of primary and secondary memory; Atkinson and Shiffrin's stage model of memory; other models including Blooms taxonomy and Sternberg's Information Processing Approach; Attention and perception – meaning, types, theories and models; Consciousness.

Unit 3: Learning

Learning – foundations, approaches and theories; Cognitive approaches of learning – meaning, principles theories and models; Memory – foundations, types; Behavioural approaches of learning – foundations and theories - classical conditioning, operant conditioning, applied behaviour analysis; Social cognitive and constructivist approaches to learning – foundations and theories – social cognitive theory, Self-regulated learning; learning styles – meaning, types and applications in learning.

Unit 4: Judgement, Choice and Decision-making

Human judgement – meaning, nature, randomness of situations, theories and models; Choice – meaning, criteria for evaluating options; theories and models of human choice; Choice architecture; Decision-making – Meaning, problem analysis; steps and techniques of decision-making under different contexts.

Block 3: Human Behaviour in the Society

Unit 1: Attitudes and Influence

Attitudes - meaning, assumptions, types, theories and models of attitude formation; methods of changing attitudes, Relating to others - liking, attraction, helping behaviour, prejudice, discrimination and aggression; Liking/ affect – meaning, types and theories; Attraction – meaning, types and theories; Persuasion – meaning, theories and techniques; Social influence and groups – conformity, compliance and obedience.

Unit 2: Social Judgement, Social Identity and Inter-Group Relations

Social judgement – meaning, frame of reference, stereotyping; The judgement of attitude models; Attribution – meaning, theories; Rational decision making; Social identity – meaning, types; assessment; Groups – meaning, types, group processes; sustainability of groups; Inter group processes and theories social learning.

PRACTICAL

- Understanding perception – Attentional Blink and Repetition Blindness exercise
- Understanding attention - Testing selective attention capacity and skills and processing speed ability through Stroop test

- Hands-on experience in the techniques for assessing creative thinking – divergent and convergent thinking
- Lab exercise in applying Maslow's need hierarchy to assess motivation
- Learning - Classical conditioning and operant conditioning
- Assessing learning styles through Barsch and Kolb inventories
- Practical experience in building self-esteem
- Assessment of emotional intelligence
- Exercises in problem solving
- Exercises in visual perception
- Measuring self-concept using psychometric tools
- Experiment on factors influencing information processing
- Assessment of attitudes
- Hands on experience in methods of persuasion
- Field experience in assessing social judgement
- Simulation exercise to understand decision-making under different situations
- Exercise in rational decision-making

RESOURCES

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EXT 504 :Research Methodology in Extension

2+1

THEORY

Block 1: Introduction to Behavioural Research

Unit 1: Nature of Behavioural Research

Methods of knowing; Science and scientific method; Behavioural research – Concept, aim, goals and objectives; Characteristics and Paradigms of research; Types of behavioural research based on applications, objectives and inquiry; Types of knowledge generated through research – historical, axiological, theoretical and conceptual knowledge, prior research studies, reviews and academic debate; Role of behavioural research in extension; Careers in behavioural research.

Unit 2: The Behavioural Research Process

Basic steps in behavioural research – Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools; Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.

Block 2: Steps in Behavioural Research Process

Unit 1: Formulating a Research Problem

The research problem and research topic - definitions; Importance of formulating a research problem; Sources of research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem; Strategies for writing research problem statement; Research purpose statement; Research questions – Types, Criteria for selecting research questions, techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging the objectives.

Unit 2: Reviewing the Literature

Review-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical; Literature review for quantitative and qualitative studies; Steps in conducting literature review – Identify key terms, locate literature, critical evaluation and selection; organising literature and writing literature review.

Unit 3: Identifying Variables and Hypotheses

Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research; Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; Techniques of identifying concepts, constructs and variables - Types of concepts; Types of variables-causal relationship, the study design; and the unit of measurement; Types of definitions-Types of propositions and hypotheses. Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval and ratio; Criteria for choosing measurement levels for variables.

Unit 4: Formulating Research Designs, Methods and Tools

Research designs – Definition, purpose and functions; Research Design as Variance Control - MAXMINCON Principle; Criteria for selecting a suitable Research Design; Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis; Qualitative designs - ethnographic, grounded theory, phenomenological and Narrative research; Mixed method designs – Action research design; Translational research; Elements of research design - Research strategies, Extent of researcher interference, Study setting, Unit of analysis and Time horizon. Sources of errors while specifying research designs. Internal and external validity; Choosing right research design; Triangulation - Importance in behavioural research, Types of triangulations. Research methods: Designing research Instruments – questionnaires, interview schedules; tests – knowledge tests, behaviour performance tests; scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory rural appraisal.

Unit 5: Selecting Sample

Sampling - population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample; Types of sampling, Methods of drawing a random sample, Sampling with or without replacement, Types of sampling - Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; Non-probability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling; Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; Generalisation – Importance, Types of generalisations.

Unit 6: Collecting Data

The process of collecting data – Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection. Testing goodness of measures through item analysis - Reliability and validity; Types of validity – Content validity: Face and content validity, Criterion-related validity: concurrent and predictive validity, Construct validity: convergent, and discriminant validity, factorial validity, and nomological validity; Types of reliability Test-Retest, Parallel forms, Inter-item consistency reliability, Split-half reliability Factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitative research.

Unit 7: Analyzing and Interpreting the Data

Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses; Parametric analysis – Descriptive and inferential statistics, Hypothesis testing - Type I and Type II errors. Concepts in hypothesis testing - Effect Size, α , β , and Power, P Value; Multivariate data analysis – regression, factor analysis, cluster analysis, logistic regression and structural equation modelling. Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; Methods of interpreting data and drawing inferences - The Ladder of Inference; Methods of communicating and displaying analysed data.

Unit 8: Reporting and Evaluating Research

Writing reports and research publications; Evaluation Methodology

PRACTICALS

- Selecting a research problem and writing problem statement
- Narrowing down research problem to purpose, research questions and objectives
- Choosing, evaluating and reviewing research literature
- Selection of variables through construct conceptualisation and defining variables
- Choosing research design based on research problem
- Choosing right sampling method and estimating sample size
- Developing research methods and tools – questionnaires, interview schedule, check lists and focus group guides
- Writing a research proposal
- Field data collection using research methods and tools
- Testing reliability and validity of research instruments
- Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives of research
- Writing report, writing of thesis and research articles
- Presentation of reports

RESOURCES

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EXT 505 : Capacity Development 2+1

THEORY

Block 1: Introduction to Capacity Development

Unit 1: Capacity Development–An Overview

Training, capacity building, capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types and levels of capacities - Institutional capacities (include the rules, regulations and practices that set the overarching contextual environment), Organisational capacities (how various actors come together to perform given tasks), Individual capacities (technical, functional and leadership skills). Types of capacity building - Based on structure (structured, semi-structured & unstructured), Based on context (orientation, induction and refresher), and other categories (online, Webinar, distance etc.). Components of capacity development; Capacity development cycle.

Unit 2: Capacity Development- Approaches and Strategies

Capacity Development Dilemma- Theory versus Practice, Trainee versus Task, Structured versus Unstructured, Generic and Specific; Approaches in Capacity Development - Informative approach, Participatory approach, Experimental approach/Experiential, Performance based approach; Capacity Development Strategies- Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy

Unit 3: Planning and Organization of Capacity Development Programmes

Steps in Designing and Planning of Capacity Development- Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and

objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design, Step 7. Prepare evaluation form, Step 8. Determine follow-up activities; Organizing capacity development programme; Operational arrangements at different stages- Before the programme, During the programme, Middle of the programme, At the end of the programme, After the programme, Follow up; Stakeholders' responsibilities.

Block 2: Capacity Development Needs Assessment

Unit 1: Planning and Organization of Capacity Development Programmes

Concept of Need Assessment; Approaches in Need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.

Unit 2: Capacity Development Needs Assessment Methods

Data Collection Methods in Identifying Needs - Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group Discussion, Interview, SWOT Analysis); Information and Skills required in Need Analysis; Identification of Needs through Task Analysis - Task identification, Task Analysis, Gap Analysis.

Block 3: Capacity Development Institutions and Management

Unit 1: Capacity Development Institutions

Capacity Developer (Trainer): Meaning and concept; Types of Capacity Developers (regular, *ad-hoc*, part time, guest and consultants); Roles of Capacity Developer (explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/interpreter, change agent); Good Capacity Developer – Qualities, skills and roles Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator); Capacity Development Centres and Locations; Organisation's Role in Capacity Development.

Unit 2: Capacity Development Project Formulation

Project Proposal: Concept and Meaning; Steps in Project Formulation- Review of past proposals, Consulting experts, consultants, and previous organizers, Review past project evaluation reports, Interact with the prospective beneficiaries; Format for Writing Project Proposal (LFA).

Block 4: Capacity Development Process and HRD

Unit 1: Capacity Development Methods and Tools

Capacity Development Methods –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T - group/ Laboratory methods; Factors Determining Selection of Methods - Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; Capacity Development Aids

Unit 2: Evaluation

Capacity Development Programme Evaluation - Meaning & Importance; Purpose of Evaluation; Principles of Evaluation; Types of Evaluation – Formative, Summative, Kirkpatrick's four levels of evaluation; Process of Evaluation- Evaluation at the beginning,

Evaluation during the programme, Evaluation at the end; Use of evaluation findings; Statistical Tools for evaluation.

Unit 3: Impact Assessment

Impact Assessment- Meaning, Need, Features, Benefits, Concepts; Indicators for Impact Assessment - Direct indicators, Indirect or proxy indicators, Quantitative indicators, Qualitative indicators, Result chain / hierarchy of indicators; Methods of Impact Evaluation- Learning retention of participants (KOSA), Impact on the job performance, Impact on organizational effectiveness, Impact on stakeholder's competency.

Unit 4: Human Resource Development

HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession planning, Retention), Work system (Role analysis, Role efficacy, Performance plan, Performance feedback and guidance, Performance appraisal, Promotion, Job rotation, Reward), Development system (Induction, Training, Job enrichment, Self-learning mechanisms, Potential appraisal, Succession development, Counselling, Mentor system), Self-renewal system (Survey, Action research, Organizational development interventions), Culture system (Vision, mission and goals, Values, Communication, Get together and celebrations, Task force, Small groups); Components of HRD System - Performance Appraisal, Potential Appraisal, Task System, Development System, Socialization System, Governance; Functions of HRD-Organizational Development, Career Development, Capacity Development.

PRACTICALS

- Capacity development needs assessment exercise
- Capacity development project formulation exercise
- Planning organizing and conducting an extension capacity development programme
- Designing a programme
- Writing learning objectives
- Developing objectives into curriculum
- Training plan
- Organizing capacity development workshop
- Evaluation with pre- and post-training tests
- Training methods – Practicing each method mentioned in contents as group exercise

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EXT 506 : ICTs for Agricultural Extension and Advisory Services

2+1

Theory

Block 1: Introduction to Information and Communication Technologies (ICTs) and E-extension

Unit 1: ICTs- Concepts and Status

ICTs- meaning, concepts, basics of ICTs, global and national status, types and functions of ICTs, innovations, meaning of e-Governance, e-learning, mLearning, advantages and limitations of ICTs.

Unit 2: ICTs in Knowledge Management

Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.

Unit 3: e-Extension initiatives in Agriculture and allied sectors

e-Extension, overview on Global and national e-extension initiatives, Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGO initiatives in India.

Block 2: Application of ICTs in Extension and Advisory Services

Unit 1: ICT Applications

Knowledge centres (tele centres), digital kiosks, websites and web portals, community radio, farmers call centres, mobile phone based advisory services and mobile applications (mExtension, mLearning), Self-learning CDs on Package of practices, social media, digital videos, Market Intelligence and Information Systems- ICT enabled Supply-Chains and Value-Chains/ e-Marketing (e-NAM, Agmarknet, *etc.*).

Unit 2: ICT Expert Systems

Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Fishery, Water, Weather, *etc*

Unit 3: ICT Networks

Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCs, Course CCRA, EduEx, *etc*), e-Governance Systems; digital networks among extension personnel, Farmer Producers Organizations (FPOs)/ SHGs/ Farmers Groups.

Block 3: Knowledge Management and Standards

Unit 1: Policies in Knowledge Management

Global policy/ Standards on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source *etc*; Language Technology Applications; National e-Agriculture policy/ Strategies/ guidelines.

Unit 2: Web Standards

Web standards, creating and writing for webportals, development of mobile applications, developing digital videos- story board- video recording- video editing, types of blogs and writing guidelines.

Unit 3: Social Media Applications to engage audience

Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data-analytics.

Block 4: Smart and Disruptive Technologies and Advanced Analytics for Agricultural Extension

Unit 1: Smart Technologies

Open technology computing facilities, System for data analytics/ mining/ modelling/ Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies- Analysis; Internet of Things (IoT), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.

Unit 2: Human Computer Interactions

Human Centered Learning/Ergonomics/ Human Computer Interactions-Meaning; Theories of multimedia learning - Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning, Schnotz's integrative model of text and picture comprehension, van Merriënboer's four-component instructional design model for multimedia learning; Basic Principles of Multimedia Learning - Split-attention, Modality, Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment; Advanced principles - Guided discovery, worked examples, Self-explanation, drawing, feedback, multiple representation, Learner control, animation, collaboration, prior knowledge, and working memory. Designing ICT gadgets based on human interaction principles - Interactive design-Meaning, importance; Approaches of interactive design - user-centered design, activity- centered design, systems design, and genius design; Methods of interactive design-Usability testing methods.

PRACTICALS

- Content and client engagement analysis
- Designing extension content for ICTs
- Creating and designing web portals, blogs, social media pages
- Developing digital videos
- Live streaming extension programmes and organising webinars
- Working with Farmers call centres
- Engaging with professional digital networks
- Writing for digital media

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EXT 507 : Organizational Behavior and Development

2+1

THEORY

Block 1: Programme Evaluation

Unit 1: Introduction to Evaluation

Concept of Evaluation: Meaning and concept in different contexts; Why Evaluation is Done and When? Programme planning, analyse programme effectiveness, decision making, accountability, impact assessment, policy advocacy; Objectives, types, criteria and approaches of programme evaluation, evaluation principles; the context of program evaluation in agricultural extension; Role and Credibility of Evaluator: Role as educator,

facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator.

Unit 2: Evaluation Theories

Evaluation theory vs. practice – synergistic role between practice and theory in evaluation; Evaluation theories - Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory (other theories/ approaches - Utilization-Focused Evaluation & Utilization-Focused Evaluation (U-FE) Checklist, Values Engaged Evaluation, Empowerment Evaluation, Theory-Driven Evaluation). Integration between theory and practice of evaluation:
–evaluation forums, workshops, conferences and apprenticeship/ internship.

Block 2: Evaluation Process

Unit 1: How to Conduct Evaluation

Ten Steps in programme evaluation: (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, on- going, wrap-up, follow-up) and type of evaluation study needed (needs assessment, baseline, formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques (8) Collect, analyse and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types, reporting results, reporting tips, reporting negative findings) (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programme stakeholders).

Unit 2: Evaluating the Evaluation

Evaluating the Evaluation - 10 Steps as above with focus on conceptual clarity, representation of programme components and stakeholders, sensitivity, representativeness of needs, sample and data, technical adequacy, methods used for data collection and analysis, costs, recommendations and reports.

Block 3: Programme Management Techniques

Unit 1: SWOT Analysis and Bar Charts

SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool; Conducting SWOT Analysis - Common Questions in SWOT Analysis; Advantages and Disadvantages of SWOT; Bar Charts (Gantt Charts and Milestone Charts) - Characteristics, advantages and limitations.

Unit 2: Networks

Networks – Introduction, origin and widely used networks (Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages. Networks Terminology – Activity, Dummy activity, Event (predecessor event, successor event, burst event, merge event, critical event), Earliest Start Time (EST), Latest Start Time (LST), Critical Path, Critical Activity, Optimistic time (T_o), Pessimistic time (P_o), Most likely time (T_M), Expected time (T_E), Float or Slack, Event Slack, Lead time, Lag time, Fast tracking, Crashing critical path, Activity Table, Dangers, Normal Time. Rules for Preparation of Networks and Steps in Network Preparation with example.

Block 4: Programme Evaluation Tools

Unit 1: Bennett's Hierarchy of Evaluation

Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy – Inputs, activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy

Unit 2: Logic Framework Approach (LFA)

Introduction to LFA – Background and description; Variations of LFA - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP); LFA Four-by-Four Grid – Rows from bottom to top (Activities, Outputs, Purpose and Goal & Columns representing types of information about the events (Narrative description, Objectively Verifiable Indicators (OVIs) of these events taking place, Means of Verification (MoV) where information will be available on the OVIs, and Assumptions). Advantages and Disadvantages of LFA.

Block 5: Impact Assessment

Unit 1: Introduction to Impact Assessment

Concept of Impact Assessment: Meaning, concept and purpose in different contexts; Impact Assessment Framework: Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.

Unit 2: Impact Assessment Indicators

Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services - social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

Unit 3: Approaches for Impact Assessment

Impact assessment approaches – Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, Non-experimental). Econometric Impact Assessment: - (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Adoption Quotient, etc). Qualitative and Participatory Impact Assessment Methods.

Unit 4: Environment Impact Assessment (EIA)

Concept of EIA – Introduction, What it is? Who does it? Why it is conducted? How it is done?; Benefits and important aspects of EIA-risk assessment, environmental management and post product monitoring. Environmental Components of EIA – air, noise, water, biological, land; Composition of the expert committees and Steps in EIA process - screening, scoping, collection of baseline data, impact prediction, mitigation measures and EIA report, public hearing, decision making, monitoring and implementation of environmental management plan, assessment of alternatives, delineation of mitigation measures and EIA report; Salient Features of 2006 Amendment to EIA Notification - Environmental Clearance/Rejection, participants of EIA; Shortcomings of EIA and How to improve EIA process?

PRACTICALS

- Search the literature using web / printed resources and identify evaluation indicators for the following:
 - Utilization-Focused Evaluation
 - Values Engaged Evaluation
 - Empowerment Evaluation
 - Theory-Driven Evaluation
- Visit Directorate of Extension in your university and enquire about extension programmes being implemented / coordinated by Directorate. Develop an evaluation proposal of any one programme using ‘Ten Steps in Programme Evaluation’ discussed in the theory class.
- Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the ‘Evaluating the Evaluation’ approach.
- Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOT grid.
- Identify an on-going development programme and make-out 6 activities from the programme.
- Draw a Gantt chart for 12 months programme activities.
- Write a report on evaluation hierarchy levels and indicators as per Bennett’s hierarchy of

evaluation for any development programme or project.

- Develop LFA four-by-four grid for any development programme or project with activities, outputs, purpose and goal and objectively verifiable indicators, means of verification & assumptions.

Visit a nearby KVKs / ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK / ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

- Refer any Environment Impact Assessment report and analyse steps in EIA. Write your observations.

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503 (EXT 531) Organizational Behavior and Development

2+1

THEORY

Block 1: Organizational Behavior

Unit 1: Basics of Organization

Introduction to organizations-concept and characteristics of organizations; Typology of organizations; Theories of organizations: nature of organizational theory, Classical theories, Modern management theories, System Theory - Criticisms and lessons learnt/ analysis.

Unit 2: Basics of Organizational Behaviour

Concepts of Organizational Behaviour, Scope, Importance, Models of OB.

Unit 3: Individual Behaviour in Organizations

Introduction, Self-awareness, Perception and Attribution, Learning, Systems approach to studying organization needs and motives – attitude, values and ethical behavior, Personality, **Motivation**-Concept & Theories, Managing motivation in organizations.

Unit 4: Group Behaviour in Organization

Foundations of group, group behaviour and group dynamics, Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations; Teams in Organizations-Team building experiential exercises, INTERPERSONAL Communication and Group; Leadership: Meaning, types, Theories and Perspectives on Effective Leadership, Power and Influence, managing Conflict and Negotiation skills, Job/ stress management, decision-making, problem-solving techniques

Unit 5: Productive Behaviour and Occupational Stress

Productive behaviour - Meaning, dimension; Job analysis and Job performance – meaning, dimensions, determinants and measurement; Job satisfaction and organizational commitment - meaning, dimensions and measures roles and role clarity; Occupational stress

- meaning, sources, theories and models, effects, coping mechanism, effects and management; Occupational stress in farming, farmer groups/ organizations, research and extension organizations.

Unit 6: Organizational System

Organizations Structure- Need and Types, Line & staff, functional, committee, project structure organizations, centralization & decentralization, Different stages of growth and designing the organizational structure; Organizational Design- Parameters of Organizational Design, Organization and Environment, Organizational Strategy, Organization and Technology, Power and Conflicts in Organizations, Organizational Decision-Making; Organizational Culture vs Climate; Organizational Change; Organizational Learning and Transformation.

Block 2: Organizational Development

Unit 1: Overview of Organizational Development

Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values.

Unit 2: Managing the Organizational Development Process

Basic Component of OD Program-Diagnosis-contracting and diagnosing the problem, Diagnostic models, open systems, individual level group level and organizational level diagnosis; Action-collection and analysis for diagnostic information, feeding back the diagnosed information and interventions; Program Management- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.

Unit 3: Organizational Development Interventions

Meaning, Importance, Characteristics of Organization development Interventions, Classification of OD Interventions-Interpersonal interventions, Team Interventions, Structural Interventions, Comprehensive Interventions.

Unit 4: Organizational Development Practitioner or Consultant

Who is OD consultant? Types of OD consultants and their advantages, qualifications, Comparison of traditional consultants Vs. OD consultants, Organizational Development process by the practitioners skills and activities.

PRACTICALS

- Case Analysis of organization in terms of process – attitudes and values, motivation, leadership.
- Simulation exercises on problem-solving – study of organizational climate in different organizations.
- Study of organizational structure of development departments, study of departmentalization, span of control, delegation of authority, decision-making patterns.
- Study of individual and group behaviour at work in an organization.
- Conflicts and their management in an organization.
- Comparative study of functional and nonfunctional organizations and drawing factors for organizational effectiveness.
- Exercise on OD interventions (Interpersonal, Team, Structural, Comprehensive) with its procedure to conduct in an organization

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EXT 508 (EXT 531) Managing Extension Organizations 2+1

THEORY

Block 1: Basics of Management

Unit 1: Management- An Over view

Management and Extension management– Meaning, concept, nature and importance and theories of management. Management, administration and supervision - meaning, definition and scope; Approaches to management, Principles, functions and levels of management; Qualities and skills of a manager; Interpersonal relations in the organization; Reporting and budgeting.

Block 2: Management in different types of Extension Organizations

Unit 1: Extension Management in public, private sector and other sectors

Extension management (POSDCORB) in public sector, Department of Agriculture, Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK), SAUs, ICAR Institutes, Private sector, Cooperatives, NGOs, FPOs etc. Organizational Structure, Relations between different units- Challenges in management

Unit 2: Concepts in Management

Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions; Human Resource Management: Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development; Dealing with fund and staff shortages in different extension organizations (KVK, ATMA etc.); Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles; Authority and responsibility, Delegation and decentralization, line and staff relations; Challenges of co-ordination in extension organizations; Managing interdepartmental coordination and convergence between KVK, ATMA and line departments; Coordinating pluralism in extension services; Challenges in managing public-private partnerships (PPPs) at different levels in agricultural development in general and extension in particular; Performance appraisal – Meaning, Concept, Methods.

Block 3: Motivation and Organizational Communication

Unit 1: Motivation and Communication

Managing work motivation – Concept, Motivation and Performance, Approaches to motivation, team building; Organizational Communication – Concept, Process, Types, Networks, Barriers to Communication; Mentoring, Time management, Team work and team-building strategies; Modernization of information handling

Unit 2: Supervision and Control

Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision; Managerial Control – Nature, Process, Types, Techniques of Control, Observation, PERT and CPM, Management Information Systems (MIS): Concept, tools and techniques, MIS in extension organizations.

PRACTICALS

- Simulated exercises on techniques of decision making
- Study the structure and function of agro-enterprises, Designing organizational structure/organograms.
- Group activity on leadership development skills
- Simulated exercise to understand management processes
- Field visit to extension organizations (ATARI, KVKs, NGOs), FPOs, dairy cooperatives to understand the functions of management
- Practical exercises on PERT & CPM
- Group exercise on development of short term and long term plans for agro- enterprises
- Developing model agriculture-based projects including feasibility study, financial planning and cost-benefit analysis

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EXT 509 : Enabling Innovation 2+1

THEORY

Block 1: Agricultural Innovation Systems

Unit 1: Agricultural Innovation Systems: Concepts and Elements

Origins of the innovation systems concept-Innovation vs Invention; Agricultural Innovation System (AIS) -ToT, FSR, AKIS and AIS compared, Key insights from AIS: How Innovation takes place; Role of different actors in AIS; Importance of interaction and knowledge flows among different actors, Role of Communication in Innovation Process; Role of Extension in AIS, Different views to analyze AIS: structural view, functional view, process view and capacity view.

Unit 2: Enabling Innovation

Role of enabling environment: Policies and institutions in enabling innovation; Role of Government-Innovation Policy: Achieving coordination and policy coherence Innovation Platforms; Role of Innovation Brokers, Methodologies for AIS Diagnosis: Typologies of existing methodologies-strengths and limitations; Assessing Extension and Advisory Services within AIS; Capacity Development in AIS: Strengthening capacities to innovate.

Block 2: Scaling Up Knowledge for Innovation

Unit 1: Scaling Up: Tools, Approaches and Pathways

Scaling Up: Definitions; Changing views on scaling up: Approaches to Scaling Up: Push, pull, plant, probe: Scaling up pathways: Drivers and spaces for scaling up; Framework and Tools for Scaling up: Planning and implementing a scaling up pathways; Scalability assessment tools; Role of policies in scaling up: Influencing policies for scaling up; Innovation Management for scaling up knowledge and implications for Extension and Advisory Services.

PRACTICAL

- Identify one crop/commodity sector and use AIS framework to diagnose actors and their roles,

patterns of interaction, institutions determining interaction and the enabling policy environment and develop a AIS Diagnosis Report (Review and Key informant interviews)

- Undertake a case study on a successful case of scaling up knowledge and identify factors that contributed to its success
- Identify one specific knowledge (a technology, an approach) that has been recently introduced and develop an Up-scaling Strategy

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EXT 510 : Gender Mainstreaming 2+1

THEORY

Unit 1: Historical Perspective of Gender

Historical perspective of gender: Feminism and emergence of gender as a concept, Scope of gender studies in agriculture and rural development

Unit 2: Agrarian Importance of Gender.

Agrarian Importance of Gender: Understanding the importance of gender in national and global agriculture-Key gender issues and challenges in agriculture - Gender and value chain- Global actions to address gender-needs and strategies to address gender and women empowerment.

Block 2: Gender Related Concepts, Analysis, Gender and Technology

Unit 1: Gender Related Concepts and Divides

Gender related concepts and divides: Understanding of the concepts of gender, gender equality and equity, gender balance, gender blindness, gender relations, gender neutrality, gender bias and discrimination, gender rights, gender roles and responsibilities. Gender budgeting, Gender divides and their implications such as gender digital divide, gender access to resources and inputs divide, gender mobility divide, gender wage divide, Gender needs: practical and strategic.

Unit 2: Gender Analysis

Gender analysis: Importance, usage, prerequisites, techniques of gender analysis- Tools for gender analysis.

Unit 3: Gender and Technology

Gender and technology: How gender and technology impact each other, Gender neutral technology, Gender sensitive technology, Gender supportive assistance in technology adoption-Gender in agricultural research and extension.

Block 3: Gender Mainstreaming and Women Empowerment

Unit 1: Gender Mainstreaming

Gender mainstreaming: Importance of gender mainstreaming in agriculture, Extension strategies to address gender issues such as gender and health, nutrition, gender in agricultural value chains, gender and climate change adaptation, gender and globalization & liberalization for mainstreaming gender concerns into the national programmes and policies.

Unit 2: Women Empowerment

Women Empowerment: Importance of women empowerment, Current national women empowerment and gender indices. Women empowerment approaches (technological,

organizational, political, financial, social, legal and psychological), Case studies based on experiences and learning from various development and rural development programmes.

Unit 3: Global Best Practices, Policies and Frameworks

Global Best Practices, Policies and Frameworks: Global best practices, women empowerment and gender mainstreaming models and frameworks for addressing gender concerns in agriculture, approaches of various organizations: gender mainstreaming and special women focused programmes in agriculture and rural development.

Unit 4: Entrepreneurship Development for Women

Entrepreneurship development for women: Women entrepreneurship development in agriculture and agro processing: current status, women led enterprises, supporting organizations and schemes, Govt. policies, entrepreneurship development programme and process for women in agriculture.

PRACTICALS

- Visit to a village for understanding rural gender roles and responsibilities as groups, followed by class presentation by groups
- Exercise for capturing shifts in gender roles and responsibilities
- Conducting gender analysis in a village using gender analysis techniques
- Visit to agencies supporting women empowerment followed by report presentation. Each student to visit a different organization such as State Rural Livelihood Mission, Women Development Corporation, Department of Agriculture, Important NGOs working for women empowerment
- Exercise for identification and prioritization of issues affecting/needs for women empowerment
- Interaction with a successful women entrepreneur/ SHG

RESOURCES

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

Major Course				
S. No.	Course code as per BSMA	Proposed Course code	Course Title	Credit Hour
1.	GPB 501*	GPB 511*	Principles of Genetics	3(2+1)
2.	GPB 502*	GPB 512*	Principles of Plant Breeding	3(2+1)
3.	GPB 508	GPB 513	Mutagenesis and Mutation Breeding	3(2+1)
4.	GPB 505	GPB 514	Principles of Cytogenetics	3(2+1)
5.	GPB 511	GPB 515	Crop Breeding-I (<i>Kharif</i> Crops)	3(2+1)
6.	GPB 517	GPB 516	Germplasm Characterization and Evaluation	2(1+1)
7.	GPB 506*	GPB 521*	Molecular Breeding and Bioinformatics	3(2+1)
8.	GPB 503*	GPB 522*	Fundamentals of Quantitative Genetics	3(2+1)
9.	GPB 512	GPB 523	Crop Breeding-II (<i>Rabi</i> Crops)	3(2+1)
10.	GPB 518	GPB 524	Genetic enhancement for PGR Utilization	2(1+1)
11.	GPB 507	GPB 525	Breeding for Quality and Special Traits	3(2+1)
12.	GPB 513	GPB 526	Breeding for Vegetable Crops	3(2+1)
13.	GPB 504	GPB 531	Varietal Development and Maintenance Breeding	2(1+1)
14.	GPB 509	GPB 532	Hybrid Breeding	3(2+1)
15.	GPB 514	GPB 533	Breeding for Fruit Crops	3(2+1)
16.	GPB 515	GPB 534	Breeding for Ornamental Crops	3(2+1)
17.	GPB 516	GPB 535	Breeding for Stress Resistance and Climate Change	3(2+1)
18.	GPB 510	GPB 536	Seed Production and Certification	2(1+1)
19.	GPB 591	GPB 541	Seminar	1
20.	GPB 599	GPB 542	Research	30

GPB 501 : Principles of Genetics* 3 (2+1)

THEORY

Unit I

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

Unit II

Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

Unit III

Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

Unit IV

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

Unit V

Genomics and proteomics; metagenomics; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

PRACTICAL

- Laboratory eXercises in probability and chi-square;
- Demonstration of genetic principles using laboratory organisms;
- Chromosome mapping using three-point test cross;
- Tetrad analysis; Induction and detection of mutations through genetic tests;
- DNA eXtraction and PCR amplification;
- Electrophoresis: basic principles and running of amplified DNA;
- EXtraction of proteins and isozymes;
- Use of *Agrobacterium* mediated method and Biolistic gun;
- Detection of transgenes in the eXposed plant material;
- Visit to transgenic glasshouse and learning the practical considerations.

RESOURCES

Daniel LH and Maryellen R. 2011. *Genetics: "Analysis of Genes and Genomes"*.

Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley and Sons. 8th ed. 2006 Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education

India; Tenth edition

Lewin B. 2008. *Genes XII*. Jones and Bartlett Publ. (International Edition) Paperback, 2018 Russell PJ. 1998. *Genetics*. The Benzamin/ Cummings Publ. Co

Singh BD. 2009. *Genetics*. Kalyani Publishers (2nd Revised Edition)

Snustad DP and Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition

Stansfield WD. 1991. *Genetics*. Schaum Outline Series Mc Graw Hill

Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India; 3rd ed., 2015 Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Pubs., McGraw Hill Education; 7

edition

Uppal S, Yadav R, Singh S and Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

GPB 502 : Principles of Plant Breeding* 3 (2+1)

THEORY

Unit I

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

Unit II

Genetic basis of breeding: self- and cross-pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

Unit III

Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

Breeding methods in asexually/ clonally propagated crops, clonal selection.

Unit VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

Unit VII

Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

PRACTICAL

- Floral biology in self- and cross-pollinated species;
- Selfing and crossing techniques;
- Selection methods in segregating populations and evaluation of breeding material;
- Analysis of variance (ANOVA);
- Estimation of heritability and genetic advance;
- Maintenance of eXperimental records;

RESOURCES

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.

Chahal GS and Gossal, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches*. Narosa Publishing House.

Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.

George A. 2012. *Principles of Plant Genetics and Breeding*. John Wiley & Sons. Gupta SK. 2005. *Practical Plant Breeding*. Agribios.

Jain HK and Kharakwal MC. 2004. *Plant Breeding and—Mendelian to Molecular Approach*, Narosa Publications, New Delhi

Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House. Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Sharma JP. 2010. *Principles of Vegetable Breeding*. Kalyani Publ, New Delhi. Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society. Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.

Singh S and Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

GPB 503 :Fundamentals of Quantitative Genetics 3 (2+1)

THEORY

Unit I

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

Unit II

Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, MANOVA.

Unit III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D2, Generation mean analysis, Parent progeny regression analysis

Unit IV

Mating designs- classification, Diallel, partial diallel, $L \times T$, NCDs, and TTC; Concept of combining ability and gene action, $G \times E$ Interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation, Bi-plot analysis

Unit V

QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype

PRACTICALS

- Analysis and interpretation of variability parameters;
- Analysis and interpretation of Index score and Metroglyph;
- Clustering and interpretation of D2 analysis;
- Genotypic and phenotypic correlation analysis and interpretation;
- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation;
- A, B and C Scaling test;
- $L \times T$ analysis and interpretation, QTL analysis;
- Use of computer packages;
- Diallel analysis;
- $G \times E$ interaction and stability analysis.

RESOURCES

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

Falconer DS and Mackay J. 1998. Introduction to Quantitative Genetics (3rd Ed.).ELBS/ Longman, London.

- Mather K and Jinks JL. 1985. Biometrical Genetics (3rd Ed.). Chapman and Hall, London.
- Nandarajan N and Gunasekaran M. 2008. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
- Naryanan SS and Singh P. 2007. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
- Roy D. 2000. Plant Breeding: Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.
- Sharma JR. 2006. Statistical and Biometrical Techniques in Plant Breeding. New Age International Pvt. Ltd.
- Singh P and Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
- Singh RK and Chaudhary BD. 1987. Biometrical Methods in Quantitative Genetic analysis. Kalyani Publishers, New Delhi.
- Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
- Wricke G and Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

GPB 504 : Varietal Development and Maintenance Breeding 2(1+1)

THEORY

Unit I

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

Unit II

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

Unit III

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

Unit IV

Quality seed production technology of self and cross-pollinated crop varieties, viz., cereals and millets (wheat, barley, paddy, pearl millet, sorghum, maize and ragi, etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

Unit V

Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

PRACTICAL

- Identification of suitable areas/ locations for seed production;
- Ear-to-row method and nucleus seed production;
- Main characteristics of released and notified varieties, hybrids and parental lines;
- PGMS and TGMS;
- Identification of important weeds/ objectionable weeds;
- Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops;

- Hybrid seed production technology of important crops;
- DUS testing and descriptors in major crops;
- Variety release proposal formats in different crops.

Suggested Reading

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH. Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.

McDonald MB Jr and Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

Poehlman JM and Borthakur D. 1969. *Breeding Asian Field Crops*. Oxford & IBH. Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani. 2015 Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill

GPB 505 : Principles of Cytogenetics 3 (2+1)

THEORY

Unit I

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

Unit II

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

Unit III

Fertilization barriers in crop plants at pre-and postfertilization levels; *In-vitro* techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid vs allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixis.

Unit IV

Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, *Triticale*, *Brassica*, and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

Unit V

Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

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

in-vitro;

- Demonstration of polyploidy.

Suggested Reading

Becker K and Hardin J. 2004. *World of the Cell*. 5th Ed. Pearson Edu. 9th edition. Carroll M. 1989. *Organelles*. The Guilford Press.

Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications.

Darlington CD and La Cour LF. 1969. *The Handling of Chromosomes*. George Allen & Unwin Ltd.

Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRL Press, Oxford.

Gupta PK and Tsuchiya T. 1991. *Chromosome Engineering in Plants: Genetics, Breeding and Evolution*. Part A.

Gupta PK. 2010. *Cytogenetics*. Rastogi Publishers. Johannson DA. 1975. *Plant Micro technique*. McGraw Hill.

Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Khush GS. 1973. *Cytogenetics of aneuploids*. Elsevier. 1 edition.

Roy D. 2009. *Cytogenetics*. Alpha Science Intl Ltd.

Schulz SJ. 1980. *Cytogenetics- Plant, animals and Humans*. Springer.

Sharma AK and Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth-Heinemann publisher 2014. 3rd edition

Singh RJ. 2016. *Plant Cytogenetics* 3rd Edition. CRC Press.

Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ. 1 edition, Springer pub. Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

GPB 506 : Molecular Breeding and Bioinformatics*3(2+1)

THEORY

Unit I

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

Unit II

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

Unit III

Introduction to Comparative Genomics; Large scale genome sequencing strategies; Human genome project; Arabidopsis genome project; Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; chromatography and sequencing by Edman degradation and mass spectrometry; Endopeptidases; Nanotechnology and its applications in crop improvement.

Unit IV

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc. and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary and secondary), implications in crop improvement.

PRACTICAL

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

RESOURCES

Azuaje F and Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*.

John Wiley and Sons.

Brown TA. 1991. *Essential Molecular Biology: a practical Approach*. Oxford university press, 2002, 2nd edition

Chawala HS. 2000. *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd.

Chopra VL and Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.

Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.

Hackett PB, Fuchs JA and Messing JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.

Jollès P and Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*.

Birkhäuser.

Lewin B. 2017. *Genes XII*. Jones & Bartlett learning, 2017.

Robert NT and Dennis JG. 2010. *Plant Tissue Culture, Development, and Biotechnology*. CRC Press.

Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.

Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani Publishers, New Delhi. Watson J. 2006. *Recombinant DNA*. Cold Spring harbor laboratory press.

GPB 507 : Breeding for Quality and Special Traits³⁽²⁺¹⁾

THEORY

Unit I

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement - A human perspective.

Unit II

Breeding for grain quality parameters in rice and its analysis; Golden rice and aromatic rice: Breeding strategies, achievements and application in Indian conte Xt; Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

Unit III

Breeding for quality improvement in Sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits; Genetic resource management for sustaining nutritive quality in crops.

Unit IV

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

Unit V

Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Classification and importance, Nutritional genomics and Second generation transgenics.

PRACTICAL

- Grain quality evaluation in rice; Correlating ageing and quality improvement in rice;
- Quality analysis in millets;
- Estimation of anti-nutritional factors like tannins in different varieties/ hybrids: A comparison;

- Quality parameters evaluation in wheat, pulses and oilseeds;
- Evaluation of quality parameters in cotton, sugarcane and potato;
- Value addition in crop plants;
- Post-harvest processing of major field crops;
- Quality improvement in crops through tissue culture techniques;
- Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures;
- Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

SUGGESTED READING

Chahal GS and SS Ghosal. 2002. *Principles and procedures of plant breeding - Biotechnological and Conventional approaches*, Narosa Publications
 Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 2018.

FAO 2001. *Speciality Rices of the World - Breeding, Production and Marketing*. Oxford & IBH, 1 Nov 2001.

Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.

Gupta SK. 2007. *Advances in Botanical Research* Vol. 45 Academic Press USA.
 Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.

Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
 Singh BD. 1997. *Plant Breeding*. Kalyani Publishers, New Delhi.

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

GPB 508 : Mutagenesis and Mutation Breeding3 (2+1)

THEORY

Unit I

Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations; Detection of mutations. Paramutations in crops plants.

Unit II

Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations. Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects – RBE and LET relationships; Effect of mutations on DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Dosimetry -Objects and methods of treatment; Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects; Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume.

Unit III

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

Unit IV

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

Unit V

Use of mutagens in creating oligogenic and polygenic variations – Case studies; *In-vitro* mutagenesis – Callus and pollen irradiation; Handling of segregating M_2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

Practical

- Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents:Physical mutagens and Chemical mutagens;
- Learning on Radioactivity- Production source and isotopes at BRIT, Trombay, Learning about gamma chamber;
- Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes;
- Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens;
- Procedures in combined mutagenic treatments;
- Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;

Suggested Reading

Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.

Chadwick KH and Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer- Verlag.

Cotton R, Edkin E and Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.

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Shu QY, Forster BP and Nakagawa N. 2012. *Plant Mutation Breeding and Biotechnology*.

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GPB 509 :Hybrid Breeding 3(2+1)

Theory

Unit I

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self- and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas –

Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

- Characterization of male sterile lines using morphological descriptors;
- Restorer line identification and diversification of male sterile sources;
- Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them;
- Diversification and restoration;
- Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeon pea;
- Understanding the difficulties in breeding apomicts;
- Estimation of heterotic parameters in self, cross and asexually propagated crops;
- Estimation from the various models for heterosis parameters;
- Hybrid seed production in field crops—an account on the released hybrids, their potential, problems and ways of overcoming it;
- Hybrid breeding at National and International level, opportunities ahead.

RESOURCES

Agarwal RL. 1998. *Fundamental of Plant Breeding and hybrid Seed Production*. Science Publisher London.

Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.

Ben HL. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.

Chal GS and Gossal SS. 2002. *Principles and procedures of Plant Breeding, Biotechnology and Conventional Approaches*. Narosa Publishing House. New Delhi

De JG. 1988. *Population Genetics and Evolution*. Springer-Verlag. 30 January 2012 Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.

Mettler LE and Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall. 25 April 1988

Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons. 2013 Mukherjee BK. 1995. *The Heterosis Phenomenon*. Kalyani Publishers, New Delhi.

Proceedings of *Genetics and Exploitation of Heterosis in Crops – An International Symposium Cimmyt*, 1998.

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Srivastava S and Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ. Virmani SS. 1994. *Heterosis and Hybrid Rice Breeding. Monographs of Theoretical and Applied Genetics*, Springer-Verlag.

GPB 510 : Seed Production and Certification 2(1+1)

THEORY

Unit I

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

Unit II

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

Unit III

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

Unit IV

Floral structure, pollination mechanism and methods and techniques of seed production in major pulses and oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor and Sunflower.

Unit V

Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops

Unit VI

Seed certification - history, concept, objectives; Central seed certification board Seed certification agency/ organization and staff requirement; Legal status - Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field

PRACTICAL

- Planting design for variety- hybrid seed production techniques, planting ratio of male and

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

RESOURCES

- Agrawal PK and Dadlani M. 1987. *Techniques in Seed Science and Technology*, South Asian Publishers, Delhi.
- Agrawal RL. 1997. *Seed Technology*, Oxford & IBH Publishing.
- Anon, 1965. *Field Inspection Manual and Minimum Seed Certification Standards*, NSC Publication, New Delhi.
- Anon. 1999. *Manual of Seed Certification procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi. Kelly AF. 1988. *Seed Production of Agricultural Crops*. John Wiley, New York.
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- Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. *Seed Legislation in India*. Agrobios (India), Jodhpur, Rajasthan.
- Singhal NC. 2003. *Hybrid Seed Production in Field Crops*, Kalyani Publications, New Delhi Tunwar NS and Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

PB 511 : Crop Breeding I (Kharif Crops) 3(2+1)

THEORY

Unit I

Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, eXamples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding.

Maize: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance,

heterosis breeding, released varieties, eXamples of MAS used for improvement- QPM and Bt maize – strategies and implications.

Small millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc.

Unit II

Pigeon pea: evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, eXamples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes.

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

Other pulses: Urdbean, mungbean, cowpea,: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, eXamples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

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

Unit IV

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

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

Unit V

Sugarcane: Evolution and distribution of species and forms, wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance, etc.

Forage crops: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance, etc.

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

Practical

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

RESOURCES

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN and Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I.

Pulses and Oilseeds. Oxford & IBH.

Chandraratna MF. 1964. *Genetics and Breeding of Rice*. Longmans.

Chopra VL and Prakash S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH. Gill KS. 1991. *Pearl Millet and its Improvement*. ICAR.

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- Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.
- Murty DS, Tabo R and Ajayi O. 1994. *Sorghum Hybrid Seed Production and Management*.
ICRISAT, Patancheru, India.
- Nanda JS. 1997. *Manual on Rice Breeding*. Kalyani Publishers.
- Parthasarathy VA. 2017. *Spices and Plantation Crops Vol.1 (Part A) Breeding of Horticultural Crops Vol.1 (Part-B)*, Today and Tomorrow Printers and Publishers
- Poehlman, JM. 1987. *Breeding of Field Crops*. AVI Publishing Co. Inc. East Post Connecticut, USA.
- Ram HH and Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.
- Sharma, AK. 2005. *Breeding Technology of Crop Plant*. Yesh Publishing House, Bikaner
Slater GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.
- Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. *Crop Breeding in India*.
International Book Distributing Co.
- Walden DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.

GPB 512 : Crop Breeding-II (Rabi Crops) 3(2+1)

Theory

Unit I

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

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

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

Unit II

Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress

resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, eXamples of MAS used for improvement.

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

Unit III

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

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

Unit IV

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

Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V

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

RESOURCES

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN and Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I.

Pulses and Oilseeds. Oxford & IBH.

Gupta SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. I. Springer, USA. Gupta

SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. II. Springer, USA. Gupta SK.

2016. *Breeding of Oilseed Crops for Sustainable Production*. Academic Press, USA. Kannaiyan S,

Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.

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GPB 512 : Crop Breeding-II (*Rabi* Crops)

3(2+1)

THEORY

Unit I

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

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

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

Unit II

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

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

Unit III

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

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

Unit IV

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

Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress

resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V

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

PRACTICAL

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

RESOURCES

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN and Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I.

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Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and*
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John Wiley & Sons.

GPB 513 : Breeding Vegetable Crops 3(2+1)

THEORY

Unit I

Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II

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

Unit III

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

Unit IV

Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol.

Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V

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

PRACTICAL

- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
- Hybridization and handling segregating generations;
- Induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops;
- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops;
- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
- Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

RESOURCES

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GPB 514 (GPB 533) Breeding Fruit Crops 3(2+1)

THEORY

Unit I

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

Unit II

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

Unit III

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

Unit IV

Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate, Pineapple and Guava, Apple and other Rosaceous crops and region specific fruit crops.

PRACTICAL

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

RESOURCES

- Bhojwani SS and Razdan MK. 2006. *Plant Tissue Culture -Theory and Practice*. Elsevier Publication, Amesterdam.
- Chadha KL and Pareek, OP. 1996. (Eds.). *Advances in Horticulture*. Vol. I to IV. MalhotraPubl. House, New Delhi.
- Chadha KL and Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House, New Delhi.
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- Moore JN and Janick Jules. 1996. *Methods in Fruit Breeding*. Purdue University Press, South Campus Court D., USA.
- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK. and Mohanadas S. 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash, Kolkata.
- Ray PK. 2002. *Breeding of Tropical and Sub-tropical Fruits*. Narosa Publishing House, NewDelhi.
- Simmonds NW. 1976. *Evolution of Crop Plants*, Orient Longman, London.

GPB 515 : Breeding Ornamental Crops 3(2+1)

THEORY

Unit I

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

Unit II

Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, *Chrysanthemum*, Tuberose, *Gerbera*, *Gladiolus*, *Dahlia*, *Lilium*, *Gaillardia*, *Petunia*, *Bougainvillea*, Pansy, Marigold, *Geranium*, *Antirrhinum*, China aster, Orchids, *Carnation*, *Hibiscus*, etc.

Unit III

Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its eXploitation, production of F1 hybrids and utilization of male sterility.

Unit IV

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

PRACTICAL

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

RESOURCES

Alexander V. 2002. *Breeding for ornamentals: Classical and Molecular Approaches*. Kluwer Academic Publishers, London.

Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons. INC. New York.

Bhattacharjee SK and De LC. 2003. *Advanced Commercial Floriculture* Vol. 1. Aavishkar

Publishers & Distributors, Jaipur.

Bose TK and Yadav LP. 2003. *Commercial Flowers*. Naya Prokash Publishers, Kolkata.

Chadha KL and Bhattacharjee SK. *Advances in Horticulture* Vol. 12, Malhotra Publishing

House, New Delhi.

Mc Donald MB and Kwong FY. 2005. *Flower Seeds Biology and Technology*, CABI Publishing, Oxfordshire, UK.

Watts L. 1980. *Flower and Vegetable Plant Breeding*. Grower Books

GPB 516 : Breeding for Stress Resistance and Climate Change 3(2+1)

THEORY

Unit I

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

Unit II

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

Unit III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/ sodicity; High/ low temperature, wind, etc.; Stress due to soil factors and mineral toxicity;

Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Unit IV

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

Unit V

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

I. Practical

- Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them for diseases caused by fungi and bacteria;
- Symptoms and data recording; use of MAS procedures;
- Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level;
- Phenotypic screening techniques for nematodes and borers; Ways of combating them;
- Evaluating the available populations like RIL, NIL, etc. for pest resistance;
- Use of standard MAS procedures. Breeding strategies - Weeds – ecological, environmental impacts on the crops;
- Breeding for herbicide resistance;
- Screening crops for drought and flood resistance; factors to be considered and breeding strategies;
- Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies;
- Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

RESOURCES

Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.

Christiansen MN and Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*.

Wiley International.

Fritz RS and Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.

Li PH and Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York Springer

Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA, ARS, Washington DC.

MaXwell FG and Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons. Wiley-Blackwell.

Roberto F. 2018. *Plant Breeding for Biotic and Abiotic Stress Tolerance*. Springer.

Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths. Sakai

A and Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.

Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.

Turener NC and Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*.

John Wiley & Sons.

van der Plank JE. 1982. *Host-Pathogen Interactions in Plant Disease*. Academic Press.

GPB 517 : Germplasm Characterization and Evaluation 2(1+1)

THEORY

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Unit III

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

Practical

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

RESOURCES

Brown AHD, Clegg MT, Kahler AL, Weir BS (eds.) 1990. *Plant Population Genetics, Breeding, and Genetic Resources*, Sinauer Associates, USA.

Frankel R and Galun E 1977. *Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics*, Springer-Verlag, Berlin, Heidelberg.

Hayward MD, Boserak NO and Romagosa I. 1993. *Plant Breeding: Principles and Practices*, Chapman & Hall.

Holden JHN and Williams JT 1984. *Crop genetic resources: conservation and evaluation*, IBPGR.
Puzone, L and Th. Hazekamp 1996. *Characterization and Documentation of Genetic Resources*

Utilizing Multimedia Database. NBPGR, New Delhi.

Rana RS, Sapra RL, Agrawal RC and Gambhir R 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.

Stoskopf NC 1993. *Plant Breeding: Theory and Practice*, Westview Press.

Sundeeep Kumar, *et al.* 2016. *Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases*. PLoS One Vol 11, pages 0167702.

Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. *Plant Genetic Resources Evaluation: Principles and Procedures*, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

GPB 518 : Genetic enhancement for PGR Utilization 2 (1+1)

THEORY

Unit I

Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi eXotics, creating and managing variation, basic concepts to set up a successful pre-breeding programme.

Unit II

Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi eXotics and other unadapted germplasm, identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

Unit III

Parental selection for prebreeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical approaches for gene transfer such as alien addition and substitution, segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, fluorescence microscopy, embryo rescue methods, pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre- and post-zygotic barriers.

PRACTICAL

- Characterization of CWRs by visiting the fields;
- Screening methods for special traits-biotic and abiotic resistance;
- Screening for nutritional traits;
- Crossability studies in CWRs of cereals, legumes, oilseeds, vegetables. Assessment of pre and post-zygotic barriers in wide hybridization crosses;
- Pollen storage studies;
- Special requirements for growing CWRs, inducing flowering by manipulating day length,

temperature, chemical spraying, etc.

RESOURCES

- Andey Pereira. 2006. *Plant Reverse Genetics*, Methods and Protocols, Humana Press
- Bisht *et al.* 2004. Broadening the genetic base of sesame (*Sesamum indicum* L.) through genetic enhancement. *Plant Genetic Resources* **2**(3): 143–151.
- Dale JW and von Schantz M. 2007. *From genes to genomes. Concepts and applications of DNA technology*. John Wiley & Sons Ltd., Chichester, England.
- Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E. Simon (eds.), *Advances in new crops*. Timber Press, Portland.
- Goodman, RM. 2004. *Encyclopedia of plant and crop science*. Marcel Dekker Inc., Switzerland.
- Kimber, G and Feldman, M. 1987. *Wild Wheat: An introduction*. Special report 353, College of Agriculture, University of Missouri-Columbia.
- Lynch M. and Walsh B. 1998. *Genetics and analysis of quantitative traits*. Sinauer Associates Inc., MA, USA.
- Murphy D. 2007. *Plant breeding and biotechnology: Societal context and the future of agriculture*. Cambridge University Press, Cambridge, UK.
- Ram JS. 2010. *Plant Cytogenetics*. CRC Press.
- Ramanatha Rao V, Brown AHD, Jackson M. 2001. *Managing Plant Genetic Diversity*. CABI publication.
- Sharma S, Upadhyaya HD, Varshney RK, *et al.* 2013. Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. *Front. Plant Sci.* **4**: 309.
- Yunbi Xu. 2010. *Molecular plant breeding*, CABI publishers

Ph.D. Genetics and Plant Breeding

Ph.D. Programme: Major Courses				
S. N.	Course No. as per BSMA	Proposed Course No.	Course Title	Credit Hour
1.	GPB 601*	GPB 611*	Advances in Plant Breeding Systems	3(3+0)
2.	GPB 602	GPB 612	Advances in Biometrical Genetics	3(2+1)
3.	GPB 607	GPB 613	Crop Evolution	3(3+0)
4.	GPB 608	GPB 614	Breeding Designer Crops	2(1+1)
5.	GPB 605*	GPB 621*	Genomics in Plant Breeding	3(3+0)
6.	GPB 603	GPB 622	Molecular Cytogenetics for Crop Improvement	2(2+0)
7.	GPB 606	GPB 623	Population Genetics	2(2+0)
8.	GPB 609*	GPB 624*	IPR and Regulatory Mechanism (e-course)	1(1+0)
9.	GPB 604	GPB 625	Plant Genetics Resources, Conservation and Utilization	2(2+0)
11.	GPB 691	GPB 641	Doctoral Seminar I	01
12.	GPB 692	GPB 642	Doctoral Seminar II	01
13.	-	GPB 643	Comprehensive	NC (S/NS)
13.	GPB 699	GPB 644	Thesis/ Research	75

GPB 601 : Advances in Plant Breeding Systems* 3(3+0)

THEORY

Unit I

Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer.

Unit II

Plant Breeding methodologies: Classic versus modern; Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

Unit III

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities.

Unit IV

Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotically germplasm, introgression libraries.

Unit V

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

Unit VI

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

Unit VII

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and submergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation, greenhouse gases and carbon sequestration; Breeding for bio-fortification.

RESOURCES

Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.

Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.

Briggs FN and Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.

Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan. Hayes HK, Immer FR and Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.

Kang MS and Priyadarshan PM (Edit.). 2007. *Breeding Major Food Staples*. Blackwell Publishing.

Kole C. 2013. *Genomics and Breeding for Climate-Resilient Crops*. Springer. Volume 2-Target Traits.

Mandal AK, Ganguli PK and Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS. Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill. Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.

Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani Publishers, New Delhi.

Singh P. 1996. *Essentials of Plant Breeding*. Kalyani Publishers, New Delhi. Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

GPB 602 : Advances in Biometrical Genetics 3(2+1)

THEORY

Unit I

Continuous variation-evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques-differences, population types, approaches; various types of metrics, F₂, F₃ and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

PRACTICAL

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

RESOURCES

- Bos I and Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall. Dabholkar AR.1993. *Elements of Biometrical Genetics*. Concept Publishing Co. New Delhi. Falconer DS and Mackay J. 1996. *Introduction to Quantitative Genetics* (4 Ed.). ELBS/ Longman, London.
- Mather K and Jinks JL. 1985. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.
- Nandarajan N and Gunasekaran M. 2008. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
- Roy D. 2000. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.
- Singh P and Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
- Singh RK and Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani Publishers, New Delhi.
- Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
- Wricke G and Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

GPB 603 :Molecular Cytogenetics for Crop Improvement 2(2+0)

THEORY

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Cytogenomics: Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location.

Unit VI

Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distant hybridization, barriers to interspecific and intergeneric hybridization; Behaviour of interspecific and intergeneric crosses.

I. Suggested Reading

Clark MS and Wall WJ. 1996. *Chromosomes: The Complex Code*. Chapman & Hall. 30 June 1996

Conger BV. (Ed.). 1981. *Cloning Agricultural Plants via in-vitro Techniques*. CRC Press. 31 January 2018

Constabel F and Vasil IK. (Eds.). 1988. *Cell Culture and Somatic Cell Genetics of Plants*. Vol.

V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.
Gupta P K. 2006. *Cytogenetics*. Rastogi Publisher

Lal R and Lal S. (Eds.). 1990. *Crop Improvement Utilizing Biotechnology*. CRC Press.
Mantel SH and Smith H. 1983. *Plant Biotechnology*. Cambridge University Press.

Sen SK and Giles KL. (Eds.). 1983. *Plant Cell Culture in Crop Improvement*. Plenum Press. 13 July 2013

Yao-Shan F. 2002. *Molecular Cytogenetics: Protocols and Application*. Human Press

GPB 604 : Plant Genetic Resources, Conservation and Utilization 2(2+0)

THEORY

Unit I

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

Unit II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and eXchange to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling, clonal repositories, genetic stability under long term storage condition.

Unit III

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

Unit IV

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

Unit V

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

RESOURCES

Ellis RH, Roberts EH and White Head J. 1980. *A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks*. FAO/ IBPGR PI. Genet. Resources News 41-3-18.

Frankel OH and Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, Cambridge.

Paroda RS and Arora RK.1991. *Plant Genetic resource Conservation and management*, NBPGR, New-Delhi.

Simmonds NW. 1979. *Principles of Crop Improvement*, Longman.

Westwood MN. 1986. *Operation Manual for National Clonal Germplasm Repository*. Processed Report. USDA-ARS and Oregon State Univ. Oregon, USA.

Withers LA. 1980. *Tissue Culture Storage for Genetic Conservation*. IBPGR Tech. Rep. IBPGR, Rome, Italy.

GPB 605 : Genomics in Plant Breeding* 3(3+0)

THEORY

Unit I

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA.

Unit II

Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

RESOURCES

Alonso JM, Stepanova AN. 2015. *Plant Functional Genomics: Methods and Protocols*. Springer. Chopra VL, Sharma RP, Bhat SR and Prasanna BM. 2007. *Search for New Genes*. Academic

Foundation, New Delhi.

Hackett PB, Fuchs JA and Messing JW. 1988. *An Introduction to Recombinant DNA Technology— Basic Experiments in Gene and Manipulation*. 2nd Ed. Benjamin Publication Co.

Primose SB and Twyman RM. 2006. *Principles of Gene Manipulation and Genomics*. 7th Ed.

Wiley-Blackwell Publishing.

Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Laboratory Press.

Singh BD. 2005. *Biotechnology: Expanding Horizons*. Kalyani Publishers, New Delhi. Somers DJ, Langridge P, Gustafson JP. 2009. *Plant Genomics: Methods and Protocols*. Springer.

GPB 606 : Population Genetics 2(2+0)

THEORY

Unit I

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

Unit II

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

Unit III

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

Unit IV

Mating systems, Random mating population, Nonrandom mating: selfing –inbreeding coefficient, panmictic indeX, sibmating, Assortative mating and disassortative mating; Pedigree populations and close inbreeding, Estimation of linkage

disequilibrium, Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops; Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homeostasis- Adaptive organization of gene pools; Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage- Survival of recessive and deleterious alleles in populations.

RESOURCES

Chawla V and Yadava RK. 2006. *Principles of Population Genetics – A Practical Manual*. Dept. of Genetics, CCS HAU Hisar.

Falconer DS and Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman. Jain JP, Jain J and Parbhakaran VT. 1992. *Genetics of Populations*. South Asia Books. Li CC. 1955. *Population Genetics*. The Univ. of Chicago Press.

Mather K and Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.

Sorrens D and Doniel G. 2007. *Methods in Quantitative Genetics*. Series: *Statistics for Biology and Health*. Likelihood.

Tomar SS. 1992. *Text Book of Population Genetics*. Universal Publication.

GPB 607 : Crop Evolution 3(3+0)

THEORY

Unit I

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

Unit II

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

Unit III

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution, Multifactorial genome, Intragenomic interaction, Intergenomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.

Unit IV

Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of autopolyploids; haploidy and DH-method of production and use, allopolyploids; synthesis of new crops; Case studies – Cereals, Pulses, Oilseeds, vegetables, Fibre crops, Plantation crops, Forage crops, Tuber crops, Medicinal Plants.

RESOURCES

Hancock JF. 2004. *Plant Evolution and the Origin of Crop Species*. 2nd Ed. CABI. Ladizinsky G. 1999. *Evolution and Domestication*. Springer.

Miller AJ. 2007. *Crop Plants: Evolution*. John Wiley & Sons

Smartt J and Simmonds NW. 1995. *Evolution of Crop Plants*. Blackwell.

GPB 608 : Breeding Designer Crops 2 (1+1)

THEORY

Unit I

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

Unit II

Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement; Breeding for special traits, viz., oil, protein, vitamins, amino acids, etc.; Ecospecific ideotypes, Ideotypes for high and low moisture conditions, low and high input conditions, conversion mechanism of C3 to C4 plants; Determination of genetics of above mentioned traits.

Unit III

Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

Unit IV

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

Unit V

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

PRACTICAL

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

RESOURCES

Balint A. 1984. *Physiological Genetics of Agricultural Crops*. AK Ademiaikiado. Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.

Pessarakli M. 1995. *Handbook of Plant and Crop Physiology*. Marcel Dekker. Taiz L and Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

GPB 609 : IPR and Regulatory Mechanism (e-course)* 1(1+0)

THEORY

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

RESOURCES

Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*.

CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundat

M.Sc.(Agri.) Plant Pathology

Major Course				
S. No.	Course code as per BSMA	Proposed Course code	Course Title	Credit Hour
1.	PL PATH 501*	PL PATH 511*	Mycology	2+1
2.	PL PATH 506*	PL PATH 512	Techniques in Detection and Diagnosis of Plant Diseases	0+2
3.	PL PATH 505*	PL PATH 513*	Principles of Plant Pathology	2+1
4.	PL PATH 504*	PL PATH 514	Plant Nematology	2+1
5.	PL PATH 502*	PL PATH 521*	Plant Virology	2+1
6.	PL PATH 503*	PL PATH 522*	Plant Pathogenic Prokaryotes	2+1
7.	PL PATH 516	PL PATH 523	Diseases of Fruits, Plantation and Ornamental Crops	2+1
8.	PL PATH 512	PL PATH 524	Detection and Management of Seed Borne Pathogens	2+1
9.	PL PATH 511	PL PATH 525	Chemicals and Botanicals in Plant Disease Management	2+1
10.	PL PATH 510	PL PATH 526	Ecology of Soil-borne Plant Pathogens	1+1
11.	PL PATH 509	PL PATH 527	Disease Resistance in Plants	2+0
12.	PL PATH 513	PL PATH 528	Biological Control of Plant Diseases	1+1
13.	PL PATH 514	PL PATH 529	Integrated Disease Management	2+1
14.	PL PATH 517	PL PATH 531	Diseases of Vegetable and Spices Crops	2+1
15.	PL PATH 507	PL PATH 532	Principles of Plant Disease Management	2+1
16.	PL PATH 515*	PL PATH 533	Diseases of Field and Medicinal Crops	2+1
17.	PL PATH 508	PL PATH 534	Epidemiology and Forecasting of Plant Diseases	1+0
18.	PL PATH 518	PL PATH 535	Post-Harvest Diseases	2+1
19.	PL PATH 519	PL PATH 538	Plant Quarantine and Regulatory Measures	1+0
20.	PL PATH 591	PL PATH 541	Master's Seminar	0+1
21.	PL PATH 521	PL PATH 542	Master's Research	0+30

PL PATH 501 : Mycology 2+1

THEORY

Unit I:

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.

Unit II:

The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

Unit III:

Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.

Unit IV:

Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

PRACTICAL

- Detailed comparative study of different groups of fungi;
- Collection of cultures and live specimens;
- Saccardoan classification and classification based on conidiogenesis;
- Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi;
- Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia. Oomycota;
- Somatic and reproductory structures of *Pythium*, *Phytophthora*, downy mildews and *Albugo*, Zygomycetes: Sexual and asexual structures of *Mucor*, *Rhizopus*, General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales, and Eurotiales;
- General identification characters of Pyrenomycetes, Discomycetes, Loculo- ascomycetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes;
- Characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi;
- Application of molecular approaches and techniques for identification of fungal pathogens.

RESOURCES

Ainsworth GC, Sparrow FK and Susman HS. 1973. *The Fungi – An Advanced Treatise*. Vol. IV (A & B). Academic Press, New York.

Alexopoulos CJ, Mims CW and Blackwell M. 2000. *Introductory Mycology*. 5th Ed. John Wiley & Sons, New York.

Maheshwari R. 2016. *Fungi: Experimental Methods in Biology* 2nd edn. CRC Press, US.

Mehrotra RS and Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.

Sarbhoy AK. 2000. *Text book of Mycology*. ICAR, New Delhi.

Singh RS. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.

Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York

PL PATH 502 : Plant Virology 2+1

THEORY

Unit I:

History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions. Origin and evolution of viruses and their nomenclature and classification.

Unit II:

Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatic changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

Unit III:

Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.

Unit IV:

Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival). Management of diseases caused by plant viruses.

Practical

- Study of symptoms caused by plant viruses (followed by field visit);
- Isolation and biological purification of plant virus cultures;
- Bioassay of virus cultures on indicator plants and host differentials;
- Transmission of plant viruses (Mechanical, graft and vector and study of disease development);
- Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology;
- Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array and PCR based techniques);
- Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Clustal X/W, MEGA Software).

RESOURCES

Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.

Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ and Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI, Wallington.

Gibbs A and Harrison B. 1976. *Plant Virology – The Principles*. Edward Arnold, London.

Hull R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Oxford & IBH, New Delhi.

Wilson C. 2014. *Applied Plant Virology*. CABI Publishing England.

PL PATH 503 :Plant Pathogenic Prokaryotes 3(2+1)

THEORY

Unit I

Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and gram-positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccharide structure; Membrane transport; fimbriae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S- layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

Unit II:

Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.

Unit III:

Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

Unit IV:

Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.

Unit V:

Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, Use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

Practical

- Study of symptoms produced by phytopathogenic prokaryotes;
- Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria;
- Stains and staining methods;
- Biochemical and serological characterization;

- Isolation of genomic DNA plasmid;
- Use of antibacterial chemicals/ antibiotics;
- Isolation of fluorescent *Pseudomonas*;
- Preservation of bacterial cultures;
- Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences;
- Diagnosis and management of important diseases caused by bacteria and mollicutes.

Suggested Reading

Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.

Jayaraman J and Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publishers, Ludhiana.

Mount MS and Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II Academic Press, New York.

Salle AJ. 1979. *Fundamental Principles of Bacteriology 7th edn*.

Verma JP, Varma A and Kumar D. (Eds). 1995. *Detection of Plant Pathogens and their Management*. Angkor Publ., New Delhi.

PL PATH 504 :Plant Nematology 3(2+1)

THEORY

Unit I:

Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit II:

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

Unit III:

Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit IV:

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

Unit V:

Principles and practices of nematode management; integrated nematode management.

Unit VI:

Emerging nematode problems, Importance of nematodes in international trade and quarantine.

Practical

- Studies on kinds of nematodes- free-living, animal, insect and plant parasites;
- Nematode extraction from soil;
- Extraction of migratory endoparasites, staining for sedentary endoparasites;
- Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

Suggested Reading

Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.

Maggenti AR. 1981. *General Nematology*. Springer-Verlag, New York.

Perry RN and Moens M. 2013. *Plant Nematology*. 2nd Ed. CABI Publishing: Wallingford, UK.

Perry RN, Moens M, and Starr JL. 2009. *Root-knot nematodes*, CABI Publishing: Wallingford, UK.

Sikora RA, Coyne D, Hallman J and Timper P. 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*. 3rd edn. CABI Publishing, England.

Thorne G. 1961. *Principles of Nematology*. McGraw Hill, New Delhi.

Walia RK and Bajaj HK. 2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.

Walia RK and Khan MR. 2018. *A Compendium of Nematode Diseases of Crop Plants*, ICAR-AICRP (Nematodes), IARI, New Delhi.

PL PATH 505 :Principles of Plant Pathology 3(2+1)

THEORY

Unit I:

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit II:

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Unit III:

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

Unit IV:

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

Practical

- Basic plant pathological techniques;
- Isolation, inoculation and purification of plant pathogens and proving Koch's postulates;
- Techniques to study variability in different plant pathogens;
- Purification of enzymes, toxins and their bioassay;
- Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

Suggested Reading

Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.

Heitefuss R and Williams PH. 1976. *Physiological Plant Pathology*. Springer Verlag, Berlin, New York.

Mehrotra RS and Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi.

Singh RP. 2012. *Plant Pathology* 2nd edn. Kalyani Publishers, New Delhi.

Singh RS. 2017. *Introduction to Principles of Plant Pathology*. 5th edn. MedTech, New Delhi.

Singh DP and Singh A. 2007. *Disease and Insect Resistance in Plants*. Oxford & IBH, New Delhi.

Upadhyay RK. and Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology*. Oxford & IBH, New Delhi.

PL PATH 506 :Techniques for Detection and Diagnosis of Plant Diseases 2(0+2)

PRACTICAL

- Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid based techniques (Non-PCR–LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.);
- Phenotypic and genotypic tests for identification of plant pathogens;
- Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing;
- Volatile compounds profiling by using GC-MS and LC-MS;
- FAME analysis, Fluorescence *in-situ* Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens;
- Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

Suggested Reading

Baudoin ABAM, Hooper GR, Mathre DE and Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.

Dhingra OD and Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.

Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*, CABI Wallington.

Forster D and Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.

Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.

Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agric. Pub.Doc. Wageningen.

Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.

Trigiano RN, Windham MT and Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida. Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

PL PATH 507 :Principles of Plant Disease Management 3(2+1)

THEORY

Unit I:

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

Unit II:

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.

Unit III:

Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health *vis-a-vis* environmental hazards, residual effects and safety measures

Practical

- Phytopathometry;
- Methods of *in-vitro* evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Field evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Soil solarisation, methods of soil fumigation under protected cultivation;
- Methods of application of chemicals and bio control agents;
- ED and MIC values, study of structural details of sprayers and dusters;
- Artificial epiphytotic and screening of resistance.

RESOURCES

Fry WE. 1982. *Principles of Plant Disease Management*. Academic Press, New York.

Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington.

Marsh RW. 1972. *Systemic Fungicides*. Longman, New York.

Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. Oxford & IBH, New Delhi.

Palti J. 1981. *Cultural Practices and Infectious Crop Diseases*. Springer Verlag, New York.

Vyas SC. 1993 *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

PL PATH 508 : Epidemiology and Forecasting of Plant Diseases 1(1+0)

THEORY

Unit I

Epidemic concepts, simple interest and compound interest disease, historical development. Elements of epidemics and their interaction. Structures and patterns of epidemics. Modelling, system approaches and expert systems in plant pathology.

Unit II

Genetics of epidemics. Models for development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics. Population biology of pathogens, temporal and spatial variability in plant pathogens.

Unit III

Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment.

Unit IV

Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting, some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction. Salient features of important forecasting models.

Suggested Reading

Campbell CL and Madden LV. 1990. *Introduction to Plant Disease Epidemiology*. John Wiley & Sons, New York

Cooke B, Jones DM and Gereth KB. 2018 *The Epidemiology of Plant Diseases*. Springer Publications.

Cowling EB and Horsefall JG. 1978. *Plant Disease*. Vol. II. Academic Press, New York. Laurence VM, Gareth H and Frame Van den Bosch (Eds.). *The Study of Plant Disease Epidemics*. APS, St. Paul, Minnesota.

Nagarajan S and Murlidharan K. 1995. *Dynamics of Plant Diseases*. Allied Publ., New Delhi. Thresh JM. 2006. *Plant Virus Epidemiology*. Advances in Virus Research 67, Academic Press, New York.

Van der Plank JE. 1963. *Plant Diseases Epidemics and Control*. Academic Press, New York. Zadoks JC and Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London

PL PATH 509 : Disease Resistance in Plants 2(2+0)

THEORY

Unit I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escape, non-host resistance and disease tolerance.

Unit II

Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Unit III

Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

RESOURCES

Deverall BJ. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, New York.

Mills Dallice *et al.* 1996. *Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction*. APS, St Paul, Minnesota.

Parker J. 2008. *Molecular Aspects of Plant Diseases Resistance*. Blackwell Publ.

Robinson RA. 1976. *Plant Pathosystems*. Springer Verlag, New York.

Singh BD. 2005. *Plant Breeding – Principles and Methods*. 7th Ed. Kalyani Publishers, Ludhiana

Van der Plank JE. 1975. *Principles of Plant Infection*. Academic Press, New York.

Van der Plank JE. 1978. *Genetic and Molecular Basis of Plant Pathogenesis*. Springer Verlag. New York.

Van der Plank JE. 1982. *Host Pathogen Interactions in Plant Disease*. Academic Press, New York.

Van der Plank JE. 1984. *Disease Resistance in Plants*. Academic Press, New York.

PL PATH 510 Ecology of Soil Borne Plant Pathogens 2(1+1)

THEORY

Unit I

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Interaction of microorganisms.

Unit II

Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Conducive and suppressive soils.

Unit III

Biological control- concepts and potentialities for managing soil borne pathogens. Potential of *Trichoderma* and fluorescent *Pseudomonas* in managing plant diseases.

Practical

- Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens;
- Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils;
- Suppression of test soil-borne pathogens by antagonistic microorganisms;
- Isolation and identification of different biocontrol agents;
- Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens;
- Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants;
- Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants.

RESOURCES

Baker KF and Snyder WC. 1965. *Ecology of Soil-borne Plant Pathogens*. John Wiley, New York.

Cook RJ and Baker KF. 1983. *The Nature and Practice of Biological Control of Plant Pathogens*. APS, St Paul, Minnesota.

Garret SD. 1970. *Pathogenic Root-infecting Fungi*. Cambridge Univ. Press, Cambridge, New York.

Hillocks RJ and Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CABI, Wallington.

Mondia JL and Timper P 2016. Interactions of microfungi and plant parasitic nematodes. In: *Biology of Microfungi* (De-Wei-Lei Ed.). Springer Publications

Parker CA, Rovira AD, Moore KJ and Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

PL PATH 511 Chemicals and Botanicals in Plant Disease Management 3(2+1)

THEORY

Unit I:

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.

Unit II:

Classification of chemicals used in plant disease management and their characteristics.

Unit III:

Chemicals in plant disease control, viz., fungicides, bactericides, nematocides, antiviral chemicals and botanicals. Issues related to label claim.

Unit IV:

Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

Unit V:

Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides.

Unit VI:

Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practicals

- Acquaintance with formulation of different fungicides and plant protection appliances;
- Formulation of fungicides, bactericides and nematocides;

- *In-vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens;
- Persistence, compatibility with other agro-chemicals;
- Detection of naturally occurring fungicide resistant mutants of pathogen;
- Methods of application of chemicals.

Suggested Reading

Bindra OS and Singh H. 1977. *Pesticides – And Application Equipment*. Oxford & IBH, New Delhi.

Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. 3rd edn. Oxford & IBH, New Delhi.

Torgeson DC. (Ed.). 1969. *Fungicides*. Vol. II. An Advanced Treatise. Academic Press, New York.

Vyas SC. 1993. *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

PL PATH 512 Detection and Management of Seed Borne Pathogens 3(2+1)

THEORY

Unit I:

History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

Unit II:

Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

Unit III:

Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

Unit IV:

Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

PRACTICAL

- Conventional and advanced techniques in the detection and identification of seed- borne fungi, bacteria and viruses;
- Relationship between seed-borne infection and expression of the disease in the field.

RESOURCES

Agarwal VK and Sinclair JB. 1993. *Principles of Seed Pathology*. Vols. I & II, CBS Publ., New Delhi.

Hutchins JD and Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, Wallington.

Paul Neergaard. 1988. *Seed Pathology*. McMillan, London. Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

PL PATH 513 Biological Control of Plant Pathogens 2(1+1)

THEORY

Unit I:

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

Unit II:

Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

Unit III:

Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic microbes.

Unit IV:

Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

Practical

- Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in-vitro* and *in vivo* conditions;
- Preparation of different formulations of selected bioagents and their mass production;
- Quality parameters of biocontrol agents;
- One week exposure visit to commercial biocontrol agents production unit.

Suggested Reading

Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*. Cambridge Univ. Press, Cambridge.

Cook RJ and Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens*. APS, St. Paul, Minnesota.

Fokkemma MJ. 1986. *Microbiology of the Phyllosphere*. Cambridge Univ. Press, Cambridge.

Gnanamanickam SS (Eds). 2002. *Biological Control of Crop Diseases*. CRC Press, Florida.

Heikki MT and Hokkanen James M. (Eds.). 1996. *Biological Control – Benefits and Risks*. Cambridge Univ. Press, Cambridge.

Mukerji KG, Tewari JP, Arora DK and Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi

PL PATH 514 Integrated Disease Management 3(2+1)

THEORY

Unit I:

Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

Unit II:

Development of IDM-basic principles, biological, chemical and cultural disease management.

Unit III :

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses, vegetable crops, fruit, plantation and spice crops.

PRACTICAL

- Application of physical, biological and cultural methods;
- Use of chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM and multiple disease management in crops of regional importance as project work.

RESOURCES

Gupta VK and Sharma RC. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.

Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS and Deshpande Jayashree (Eds.). 2004. *Biotechnological Approaches for the Integrated Management of Crop Diseases*. Daya Publ. House, New Delhi.

Sharma RC and Sharma JN. (Eds). 1995. *Integrated Plant Disease Management*. Scientific Publ., Jodhpur.

PL PAT 515 Diseases of Field and Medicinal Crops 3(2+1)

THEORY

Unit I: Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize.

Unit II: Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

Unit III: Diseases of Oilseed crops- Rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

Unit IV; Diseases of Cash crops- Cotton, sugarcane.

Unit V: Diseases of Fodder legume crops- Berseem, oats, guar, lucerne.

Unit VI: Medicinal crops-*Plantago*, mulathi, liquorice, rosagrass, sacred basil, mentha, ashwagandha, Aloe vera.

PRACTICAL

- Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops;
- Collection and dry preservation of diseased specimens of important crops.

RESOURCES

Joshi LM, Singh DV and Srivastava KD. 1984. *Problems and Progress of Wheat Pathology in South Asia*. Malhotra Publ. House, New Delhi.

Rangaswami G. 1999. *Diseases of Crop Plants in India*. 4th Ed. Prentice Hall of India, New Delhi.

Ricanel C, Egan BT, Gillaspie Jr AG and Hughes CG. 1989. *Diseases of Sugarcane, Major Diseases*. Academic Press, New York.

Singh RS. 2017. *Plant Diseases*. 10th Ed. Medtech, New Delhi.

Singh US, Mukhopadhyay AN, Kumar J and Chaube HS. 1992. *Plant Diseases of International Importance*. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

PL PTH 516 Diseases of Fruits, Plantation and Ornamental Crops 3(2+1)

THEORY

Unit I:

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.

Unit II:

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.

Unit III:

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera orchids, marigold, chrysanthemum and their management.

PRACTICAL

- Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops;

- Collection and dry preservation of diseased specimens of important crops.

RESOURCES

Gupta VK and Sharma SK. 2000. *Diseases of Fruit Crops*. Kalyani Publishers, New Delhi. Pathak VN. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Singh RS. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi. Walker JC. 2004. *Diseases of Vegetable Crops*. TTPP, India.

PL PATH 517 Diseases of Vegetable and Spices Crops 3(2+1)

THEORY

Unit I:

Nature, prevalence, factors affecting disease development of tuber, bulb, leafy vegetable, crucifers, cucurbits and solanaceous vegetables. Diseases of crops under protected cultivation.

Unit II:

Symptoms and management of diseases of different root, tuber, bulb, leafy vegetables, crucifers, cucurbits and solanaceous vegetable crops.

Unit III:

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, nutmeg, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger. Biotechnological approaches in developing disease resistant transgenics

PRACTICAL

- Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

RESOURCES

Chaube HS, Singh US, Mukhopadhyay AN and Kumar J. 1992. *Plant Diseases of International Importance*. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.

Gupta VK and Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publishers, New Delhi

Gupta SK and Thind TS. 2006. *Disease Problem in Vegetable Production*. Scientific Publ., Jodhpur.

Sherf AF and McNab AA. 1986. *Vegetable Diseases and their Control*. Wiley Inter Science, Columbia.

Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.

Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New

PL PATH 518 Post-Harvest Diseases 2(1+1)

THEORY

Unit I

Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problems both by biotic and abiotic factors.

Unit II

Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.

Unit III

Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards.

Unit IV

Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarius for each product and commodity. Physical and biological agents/ practices responsible for development/ prevention of post-harvest diseases- traditional and improved practices.

PRACTICAL

- Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens *in vivo* condition;
- Comparative efficacy of different fungicides and bioagents;
- Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers;
- Visit to cold storage.

RESOURCES

Chaddha KL and Pareek OP. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.

Pathak VN. 1970. *Diseases of Fruit Crops and their Control*. IBH Publ., New Delhi.

PL PATH 519: Plant Quarantine and Regulations 1(1+0)

THEORY

Unit I:

Historical development in plant quarantine, Definitions of pest, and transgenics as per Govt. notification; Organizational set up of plant quarantine in India. relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.

Unit II:

Acts related to registration of pesticides and transgenics. History of quarantine legislations, Salient features of PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Unit III:

Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.

Unit IV:

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.

RESOURCES

Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

M.Sc. Soil Science

Major Course				
S. No.	Course code as per BSMA	Proposed Course code	Course Title	Credit Hour
1.	Soil 503*	Soil 511*	Soil chemistry	3(2+1)
2.	Soil 504*	Soil 512*	Soil mineralogy, genesis and classification	3(2+1)
3.	Soil 510	Soil 513	Analytical technique and instrumental methods in soil and plant analysis	2(0+2)
4.	Soil 507	Soil 514	Radioisotopes in soil and plant studies	2(1+1)
5.	Soil 502*	Soil 521*	Soil fertility and fertilizer use	3(2+1)
6.	Soil 501*	Soil 522*	Soil physics	3(2+1)
7.	Soil 509	Soil 523	Remote sensing and GIS technique for soil and crop studies	3(2+1)
8.	Soil 508	Soil 524	Soil, water and air pollution	3(2+1)
9.	Soil 513	Soil 525	Soil Survey and Land use Planning	2(2+0)
10.	Soil 506	Soil 531	Soil Biology and Biochemistry	3(2+1)
11.	Soil 511	Soil 532	Management of problematic soils and water	2(1+1)
12.	Soil 505	Soil 533	Soil erosion and conservation	3(2+1)
13.	Soil 512	Soil 534	Land degradation and restoration	1(1+0)
14.	Soil 514	Soil 535	Introduction to nanotechnology	3(2+1)
15.	Soil 591	Soil 541	Master's Seminar	1
16.	Soil 599	Soil 542	Master's Research	30

Soil 501 Soil Physics 3 (2+1)

THEORY

Unit I

Basic principles of physics applied to soils, soil as a three phase system.

Unit II

Soil texture, textural classes, mechanical analysis, specific surface.

Unit III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

Unit IV

Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Unit V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

Unit VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

Unit VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management. Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

PRACTICAL

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

RESOURCES

- Bayer LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley & Sons.
- Ghildyal BP and Tripathi RP. 2001. Soil Physics. New Age International.
- Hanks JR and Ashcroft GL. 1980. Applied Soil Physics. Springer Verlag.
- Hillel D. 1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.
- Hillel D. 1980. Applications of Soil Physics. Academic Press.
- Hillel D. 1980. Fundamentals of Soil Physics. Academic Press.
- Hillel D. 1998. Environmental Soil Physics. Academic Press.
- Hillel D. 2003. Introduction to Environmental Soil Physics. Academic Press.
- Indian Society of Soil Science. 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. Advanced Soil Physics. Wiley-Interscience.
- Kohnke H. 1968. Soil Physics. McGraw Hill.
- Lal R and Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
- Oswal MC. 1994. Soil Physics. Oxford & IBH.

Soil 502 Soil Fertility and Fertilizer Use 4 (3+1)

THEORY

Unit I

Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II

Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit V

Sulphur - source, forms, fertilizers and their behavior in soils; role in crops and human health; calcium and magnesium - factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit VI

Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VII

Common soil test methods for fertilizer recommendations; quantity– intensity relationships; soil test crop response correlations and response functions.

Unit VIII

Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers use in soils and crops of India;

Unit IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

Unit X

Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.

Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients (major and micro)
- Analysis of plants for essential elements (major and micro)

Suggested Reading

- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Kabata-Pendias A and Pendias H. 1992. Trace Elements in Soils and Plants. CRC Press.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
- Leigh J G. 2002. Nitrogen Fixation at the Millennium. Elsevier.
- Mengel K and Kirkby EA. 1982. Principles of Plant Nutrition. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. Micronutrients in Agriculture. 2nd Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ and Vance JF. 2002. Soils and Environmental Quality. 2nd Ed. CRC Press.
- Stevenson FJ and Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. Soil Fertility and Fertilizers. 5th Ed. Prentice Hall of India.
- Troeh FR and Thompson LM. 2005. Soils and Soil Fertility. Blackwell.

Soil 503 Soil Chemistry 3 (2+1)

THEORY

Unit I

Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

Unit III

Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit IV

Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange-innersphere and outer-sphere surface complex formation, fixation of oxyanions,

Hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

Unit V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; Concept of quantity/intensity (Q/ I) relationship; step and constant-rate K; management aspects.

Unit VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit VII

Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

Unit VIII

Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

PRACTICAL

Preparation of saturation extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics

by the serial potentiometric titration method, Extraction of humic substances,

Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl₂-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

RESOURCES

- Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.
- Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.
- Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
- Greenland DJ and Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.
- McBride MB. 1994. Environmental Chemistry of Soils. Oxford University Press.
- Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford University Press.
- Sposito G. 1984. The Surface Chemistry of Soils. Oxford University Press.
- Sposito G. 1989. The Chemistry of Soils. Oxford University Press.
- Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley & Sons.
- Van Olphen H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

Soil 504 Soil Mineralogy, Genesis and Classification 3 (2+1)

THEORY

Unit I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystal line and non-crystal line clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Unit III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit IV

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

PRACTICAL

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soil using available database in terms of soil quality

RESOURCES

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
- Dixon JB and Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.
- Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.
- USDA. 1999. *Soil Taxonomy*. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
- Wade FA and Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
- Wilding LP and Smeck NE. 1983. *Pedogenesis and Soil Taxonomy: II. The Soil Orders*. Elsevier.
- Wilding NE and Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I.

Soil 505 Soil Erosion and Conservation 3(2+1)

THEORY

Unit I

History, distribution, identification and description of soil erosion problems in India.

Unit II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

Unit III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

Unit IV

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

Unit V

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

Unit VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

PRACTICAL

- Determination of different soil erodibility indices - suspension percentage, dispersion ratio,

erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index

- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Land capability classification of a watershed
- Visits to a watersheds

RESOURCES

- Biswas TD and Narayanasamy G. (Eds.) 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Society of Soil Science No. 17.
- Doran JW and Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
- Gurm Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.
- Hudson N. 1995. Soil Conservation. Iowa State University Press.
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Oswal MC. 1994. Soil Physics. Oxford & IBH.

Soil 506 Soil Biology and Biochemistry 3 (2+1)

THEORY

Unit I

Soil biota, soil microbial ecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

Unit II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora; Root rhizosphere and PGPR.

Unit III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and proteinaceous materials, cycles of important organic nutrients.

Unit IV

organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

Unit V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

Unit VI

Biofertilizers—definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.

Unit VII

Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis – important mechanisms and controlling

factors; soil genomics and bioprospecting; soil sickness due to biological agents; Xenobiotics; antibiotic production in soil.

PRACTICAL

- Determination of soil microbial population
- Soil microbial biomass carbon
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N₂ fixation, S oxidation, P solubilization and mineralization of other micronutrients

RESOURCES

- Paul EA and Clark FE. Soil Microbiology and Biochemistry.
- Lynch JM. Soil Biotechnology
- Willey JM, Linda M. Sherwood and Woolverton CJ. Prescott's Microbiology.
- Subba Rao NS. Advances In Agricultural Microbiology

Soil 507 Radioisotopes in Soil and Plant Studies 2 (1+1)

THEORY

Unit I

Atomic structure, radio activity and units; radio isotopes-properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity

Unit II

Principles and use of radiation monitoring instruments-proportional, Geiger Muller counter, solid and liquids cintillation counters; neutron moisture meter, mass spectrometry, autoradiography

Unit III

Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

Unit IV

Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

- Storage and handling of radioactive materials
- Determination of half-life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Settingup of experiment on fertilizer use efficiency and cation exchange equilibria using radio isotopes
- Determination of A, E and L values of soil using ³²P/⁶⁵Zn
- Use of neutron probe for moisture determination

- Sample preparation and measurement of ^{15}N enrichment by mass spectro photometry/ emission spectrometry

RESOURCES

- Comer CL. 1955. Radioisotopes in Biology and Agriculture: Principles and Practice. Tata McGraw Hill.
- Glasstone S. 1967. Source Book on Atomic Energy. East West Press.
- Michael FL and Annunziata. 2003. Handbook of Radioactivity Analysis. Academic Press.

Soil 508: Soil, Water and Air Pollution 3(2+1)

THEORY

Unit I

Soil, water and air pollution problems associated with agriculture, nature and extent.

Unit II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPC standards and effect on plants, animals and human beings.

Unit III

Sewage and industrial effluents–their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

Unit IV

Pesticides–their classification, behaviour in soil and effect on soil microorganisms.

Unit V

Toxic elements–their sources, behaviour in soils, effect on nutrients availability, effect on plant and human health.

Unit VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of green house gases–carbondioxide, methane and nitrous oxide.

Unit VII

Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil andwater pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO_2 and O_2 conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

RESOURCES

- Lal R, Kimble J, Levine E and Stewart BA. 1995. Soil Management and Greenhouse Effect. CRC Press.
- Middlebrooks EJ. 1979. Industrial Pollution Control. Vol. I. Agro-Industries. John Wiley Interscience.
- Ross SM. Toxic Metals in Soil Plant Systems. John Wiley & Sons.
- Vesilund PA and Pierce 1983. Environmental Pollution and Control. Ann Arbor SciencePubl.

SOIL 509 Remote Sensing and GIS Technique for Soil, Water and Crop Studies 3 (2+1)

THEORY

Unit I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

Unit II

Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging; image processing and interpretations.

Unit III

Application of remote sensing techniques-landuse soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land identification and management.

Unit IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

Unit V

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

PRACTICAL

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photo graphs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of datafiles in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

RESOURCES

- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Elangovan K. 2006. GIS Fundamentals, Applications and Implementations. New India Publ. Agency.
- Lillesand TM and Kiefer RW. 1994. Remote Sensing and Image Interpretation. 3rd Ed. Wiley.
- Nielsen DR and Wendroth O. 2003. Spatial and Temporal Statistics. Catena Verlag GmbH.
- Star J and Esles J. 1990. Geographic Information System: An Introduction. Prentice Hall.

Soil 510 Analytical Technique and Instrumental Methods in Soil and Plant Analysis 2 (0+2)

PRACTICAL

Unit I

Preparation of solutions for standard curves, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

Unit II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit III

Principles of visible, ultra violet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractrometry; identification of minerals by X-ray by different methods, CHNS analyzer.

Unit IV

Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit V

Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; triacid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

Unit VI

Drawing normalized exchange isotherms

RESOURCES

- Hesse P. 1971. Textbook of Soil Chemical Analysis. William Clowes & Sons.
- Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.
- Keith A Smith 1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.
- Kenneth Helrich 1990. Official Methods of Analysis. Association of Official Analytical Chemists.
- Page AL, Miller RH and Keeney DR. 1982. Methods of Soil Analysis. Part II. SSSA, Madison.
- Piper CE. Soil and Plant Analysis. Hans Publ.
- Singh D, Chhonkar PK and Pandey RN. 1999. Soil Plant Water Analysis - A Methods Manual. IARI, New Delhi.
- Tan KH. 2003. Soil Sampling, Preparation and Analysis. CRC Press/Taylor & Francis.
- Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
- Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis. ELBS Longman.

Soil 511 Management of Problem Soils and Water 3 (2+1)

THEORY

Unit I

Area and distribution of problem soils—acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

Unit II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils-soluble salts, ESP, pH; physical, chemical and microbiological properties.

Unit III

Management of salt-affected soils; salt tolerance of crops- mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

Unit IV

Acid soils-nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

Unit V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

Unit VI

Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality groundwaters.

PRACTICAL

Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na^+ , K^+ , Ca^{++} and Mg^{++}) in groundwater and soil samples, Determination of anions (Cl^- , SO_4^- , CO_3^- and HCO_3^-) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils.

RESOURCES

- Bear FE. 1964. Chemistry of the Soil. Oxford & IBH.
- Jurinak JJ. 1978. Salt-affected Soils. Department of Soil Science & Biometeorology. Utah State University
- USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford & IBH.

Soil 512 Land Degradation and Restoration 1 (1+0)

THEORY

Unit I

Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.

Unit II

Land restoration and conservation techniques-erosion control, reclamation of salt-affected soils; mine land reclamation, afforestation, organic products.

Unit III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

RESOURCES

- Biswas TD and Narayanasamy G. (Eds.). 1996. Soil Management in Relation

- to Land Degradation and Environment. Bull. Indian Soc. Soil Sci. 17, New Delhi.
- Doran JW and Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Madison.
- Greenland DJ and Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. CABI.
- Lal R, Blum WEH, Vailentine C and Stewart BA. 1997. Methods for Assessment of Soil Degradation. CRC Press.
- Sehgal J and Abrol IP. 1994. Soil Degradation in India - Status and Impact. Oxford & IBH.

Soil 513 Soil Survey and Land Use Planning 2 (2+0)

THEORY

Unit I

Soil survey and its types; soil survey techniques- conventional and modern; soil series-characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for generation of soil maps, application of remote sensing and GIS in soil survey and mapping of major soil group of India

Unit II

Landform-soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)-concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Unit III

Concept and techniques of land use planning; factors governing present land use; Land evaluation method and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

Unit IV

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

PRACTICAL

- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercises using conventional and RS tools

RESOURCES

- Boul SW, Hole ED, MacCracken RJ and Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.
- Brewer R. 1976. Fabric and Mineral Analysis of Soils. John Wiley & Sons.

Soil 514 Introduction to Nanotechnology 3 (2+1)

THEORY

Unit I

General introduction: Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, an isotropy.

Unit II

Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nanowires, fullerenes (buckballs, graphene). Nanofabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nanopowders, electrode position, important nanomaterials.

Unit III

Mechanical properties, magnetic properties, electrical properties, electronic conduction with nanoparticles, investigating and manipulating materials in the nanoscale: Electron microscopy

Unit IV

Nano-biology: Interaction between biomolecules and nano-particle surface, different types of in organic materials used for the synthesis of hybrid nano-bioassemblies, application of nano-inagriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors.

PRACTICAL

- Sources of nanoparticles and its preparation by different approaches
- Electrospinning and its use in agriculture and allied sector.
- Equipments used in Nanotechnology: its principle and uses
- Acquaintances with different equipments used in nanotechnology.
- Synthesis and characterization of Ag and ZnO nanoparticles.
- Mode of action of ZnO nanoparticles against soil borne diseases
- Study on efficacy of ZnO nanoparticles as seed treating agent on plant growth parameters.

RESOURCES

- Balandin AA and Wang KL. 2006. Handbook of semiconductor nano structures and nano devices. California: American Scientific Publishers.
- Timp G. 1999. Nanotechnology. New York: Springer Verlag.
- Challa Kumar SSR. 2006. Nanotechnologies for the life sciences. Weinheim: Wiley-VCHGmbH.
- Kohler M and Frintzsche W. 2007. Nanotechnology: Introduction to nanostructuring techniques W Weinheim: Wiley-VCH Verlag GmbH.
- Kosal ME. 2009. Nanotechnology for chemicaio and biological defense. Dordrecht: Springer.

BIOCHEM-507 (BIOCHEM-511) Plant Biochemistry 3 (2+1)

THEORY

Block 1: Photosynthesis

Unit 1: Photosynthetic machinery (3 Lectures)

Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis.

Unit 2: Photosynthesis – the process (4 Lectures)

Carbon reduction in C3, C4 and CAM plants, photorespiration, sucrose-starch interconversion.

Block 2: Conversion of Photosynthates

Unit 1: Synthesis of major biomolecules (3 Lectures)

Biosynthesis of structural carbohydrates, storage proteins and lipids.

Unit 2: Nitrogen and sulphur metabolism (5 Lectures)

Basic concepts of nitrogen and sulphur metabolism: biological nitrogen fixation, nitrate assimilation in plants, sulphur chemistry and function, reductive sulphate assimilation pathway, sulphated compounds.

Block 3: Growth and Development

Unit 1: Germination and fruit ripening (4 Lectures)

Biochemistry of seed germination – stages, requirements, metabolism and mobilization of storage material; Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.

Unit 2: Phytohormones (3 Lectures)

Different classes of phytohormones, their biosynthesis and mode of action.

Block 4: Secondary Metabolites

Unit 1: Biochemistry of plant secondary metabolites (6 Lectures)

Biochemistry and significance of plant secondary metabolites – phenolics, terpenoids, alkaloids, cyanogenic glycosides and glucosinolates, effect of biotic and abiotic factors on plant metabolism and plant defense system.

PRACTICALS

- Fractionation of cell organelles,
- Estimation of starch,
- Assay of ADPG pyrophosphorylase/starch synthase,
- Assay of PAL/SOD
- Assay of PPO/LOX,
- Estimation of individual amino acids,
- Qualitative tests of secondary metabolites (alkaloids, sterols etc.)
- Content and composition of carotenoids, anthocyanin and chlorophylls
- Determination of polyphenols/phenolics
- Fractionation of storage proteins
- Estimation of glucosinolates
- Estimation of cyanogenic compounds.

RESOURCES

- Buchannan BB, Gruissem W and Jones R.L. (eds.). 2000. *Biochemistry and Molecular Biology of Plants*. 2nd edition. WILEY Blackwell
- Heldt, H-W. 2010. *Plant Biochemistry and Molecular Biology*. 4th ed. Oxford University Press
- Goodwin TW and Mercer EI. 2005. *Introduction to Plant Biochemistry*. 2nd edition. CBS
- Heldt, H-W. and Piechulla, B. 2010. *Plant Biochemistry*. 4th Edition. Elsevier
- Harinda, Makkeaand Klaus. 2007. *Plant Secondary Metabolites*. Springer
- Cseke LJ, Kirakosyan A, Kaufman PB, Warber S, Duke JA, Brielmann HL. 2006. *Natural Products from Plants*. 2ndEdition. CRC Press.

PP-505 (PP-521) Hormonal Regulation of Plant Growth and Development 3 (2+1)

THEORY

Block 1: Plant Growth and Development: Hormonal Regulation

Unit 1: Introduction to Plant Hormones

Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth

substances other than hormones, Synthetic chemicals.

Unit 2: Plant Hormones – Discovery and Metabolism

Discovery, biosynthetic pathways and metabolism of Auxin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Absciscic acid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones.

Unit 3: Physiological Role of Hormones in Plant Growth and Development

Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions,

Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Absciscic acid and use of mutants and transgenic plants in elucidating the physiological functions,

Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Brassinosteroids and Strigolactones and use of mutants and transgenic plants in

elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

Unit 4: Endogenous Growth Substances other than Hormones

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

Unit 5: Hormone Signaling

Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate,

Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

Unit 6: Key Genes Regulating Hormone Levels and Functions

Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development

Unit 8: Practical Utility of Growth Regulators in Agriculture and Horticulture

Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoceious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of

Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

VII. Practicals

- Extraction of Auxins from plant tissue
- Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological

technique

- Bioassay of auxin- effect on rooting of cuttings
- Extraction of abscisic acid (ABA) from plant tissue
- Separation and detection of ABA by HPLC/Immunological technique
- ABA bioassays- effect on stomatal movement

Preparation of samples for ethylene estimation in plant tissue

- Estimation of ethylene in plant tissues using gas chromatography
- Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut
- Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC
- Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique
- GA bioassays- effect on germination of dormant seeds
- Cytokinin- extraction from plant tissue
- Separation and detection of cytokinin by GC / GC-MS / HPLC
- Cytokinin bioassays- effect on apical dominance and senescence / stay green

Suggested Reading

- Davies P.J. 2004, *Plant Hormones: Biosynthesis, Signal Transduction and Action*, 2nd Edition.

Kluwer Academic Publishers, Dordrecht, The Netherlands.

- Hedden, P. and Thomas, S.J. 2006. *Plant Hormone Signalling*, Blackwell Publishing Ltd., Oxford, UK.
- Osborne, D.J. and McManus, M.T. 2005. *Hormones, Signals and Target Cells in Plant Development*. Cambridge University Press, New York, USA.
- Tucker, G.A. and Roberts, J.A. 2000. *Plant Hormone Protocols*. Humana Press-Springer Science, New York, USA.
- Buchanan B B, Gruissem W and Jones R L. *Biochemistry and Molecular biology of Plants*, 2nd Edition
- Lincoln Taiz and Eduardo Zeiger. *Plant Physiology and Development*, 6th Edition.
- *Teaching Tools in Plant Biology*, The American Society of Plant Biologists
- *The Arabidopsis Book*(<http://www.arabidopsisbook.org/>)

PP-501 (PP-531) Principles of Plant Physiology I - Plant Water Relations and Mineral Nutrition 3 (2+1)

Theory

Block 1: Plant Water Relations

Unit 1: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils; Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit 2: Water Absorption and Translocation

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.

Unit 3: Transpiration and Evaporative Cooling

Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata-its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard

cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

Unit 4: Water Productivity and Water Use Efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

Unit 5: Moisture Stress and Plant Growth

Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Block 2: Mineral Nutrition

Unit 1: Nutrient Elements and Their Importance

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toxicity symptoms in plants.

Unit 2: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels. Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition.

Unit 3: Concept of Foliar Nutrition

Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

VII. Practicals

- Standard solutions and preparation of different forms of solutions
 - Studies on the basic properties of water
 - Demonstration of surface tension of water and other solvents
 - Measurement of plant water status: Relative water content and rate of water loss
- Determination of water potential through tissue volume and Chardakov's test
- Determination of water potential using pressure bomb, osmometer, psychrometer
 - Determination of soil moisture content and soil water potential
 - Use of soil moisture probes and soil moisture sensors
 - Measurement of transpiration rate in plants; use of porometry
 - Measurement of CCATD and its relevance

- Demonstration and use of anti-transpirants to reduce transpiration
- Influence of potassium and ABA on stomatal opening and closing respectively
- Deficiency and toxicity symptoms of nutrients
- Effect of water stress on plant growth and development

Suggested Reading

- Vilalta JM and Forner NG. 2017. *Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso/anisohydric concept* *Plant, Cell and Environment* 40, 962–976
- Mangrich AS, Cardoso EMC, Doumer ME, Romão LPC, Vidal M, Rigol A, Novotny EH. *Improving the Water Holding Capacity of Soils of Northeast Brazil by Biochar Augmentation*. Chapter 16, pp 339–354.
- McElrone AJ, Choat B, Gambetta GA and Brodersen CR. 2013. *Water Uptake and Transport in Vascular Plants*. *Nature Education Knowledge* 4(5): 6
- Hodson RC and J Acuff. 2006. *Water transport in plants: anatomy and physiology*. Pages 163-183, *Tested Studies for Laboratory Teaching*, Volume 27 (M.A. O'Donnell, Editor). Proceedings of the 27th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 383 pages.
- Chater CCC, Caine RS, Fleming AJ, Gray JE. 2017. *Plant Physiology*, 174 (2) 624-638; DOI: 10.1104/pp.17.00183
- Dietrich P, Sanders D, Hedrich R. 2001. *The role of ion channels in light dependent stomatal opening*, *Journal of Experimental Botany*, Volume 52, Issue 363, Pages 1959–1967, <https://doi.org/10.1093/jexbot/52.363.1959>
- Sreeman SM, Vijayaraghavareddy P, Sreevathsa R, Rajendrareddy S, Arakesh S, Bharti P, Dharmappa P, Soolanayakanahally R. 2018. *Introgression of Physiological Traits for a Comprehensive Improvement of Drought Adaptation in Crop Plants*. *Front. Chem.* 6, 92.
- Seyed Yahya Salehi-Lisar Hamideh Bakhshayeshan-Agdam, (2016). *Drought Stress in Plants: Causes, Consequences, and Tolerance*. *Drought Stress Tolerance in Plants*, Vol 1 pp 1-16
- Pandey R. 2015. *Mineral Nutrition of Plants*. 10.1007/978-81-322-2286-6_20.

- Barker AV and DJ Pilbeam. 2015. Handbook of Plant Nutrition, Second Edition. Books in Soils, Plants, and the Environment Series, the 2nd Edition, CRC Press.
- Vatansever R, Ozyigit II and Filiz E. 2017. *Essential and beneficial trace elements in plants, and their transport in roots: a review. Applied biochemistry and biotechnology* 181(1), 464-482..
- Tahat MM and Sijam K. 2012. *Arbuscularmycorrhizal fungi and plant root exudates biocommunications in the rhizosphere. African Journal of Microbiology Research*, 6(46), 7295-7301.
- Rajasekar MD, Nandhini DU and Suganthi S. 2017. *Supplementation of Mineral Nutrients through Foliar Spray – A Review. Int.J.Curr.Microbiol.App.Sci.* 6(3): 2504-2513.<https://doi.org/10.20546/ijcmas.2017.603.283>
- Tarek A and Hassan ER. 2017. *Foliar application: from plant nutrition to biofortification.* Environment, Biodiversity and Soil Security. 10.21608/jenvbs.2017.1089.1006

ENT 508 : Concepts of Integrated Pest Management 2 (2+0)

THEORY

Unit I

History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons.

Unit II

Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

Unit III

Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest

risk analysis; pesticide risk analysis; costbenefit ratios and partial budgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.

Unit IV

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

Suggested Reading

Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publishers, New Delhi.

Horowitz AR and Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.

Ignacimuthu SS and Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.

Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.

Pedigo RL. 2002. *Entomology and Pest Management*. 4th Ed. Prentice Hall, New Delhi.

Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

ENT 509 : Pests of Field Crop 3 (2+1)

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.

Unit I

Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs, etc.). Insect pests of cereals and millets and their management.

Unit II

Insect pests of pulses, tobacco, oilseeds and their management.

Unit III

Insect pests of fibre crops, forage crops, sugarcane and their management.

Practical

- Field visits, collection and identification of important pests and their natural enemies;
- Detection and estimation of infestation and losses in different crops;
- Study of life history of important insect pests.

Suggested Reading

David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publishers, New Delhi

Evans JW. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.

Nair MRGK. 1986. *Insect and Mites of Crops in India*. ICAR, New Delhi.

Prakash I and Mathur RP. 1987. *Management of Rodent Pests*. ICAR, New Delhi.

Saxena RC and Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.

ENT 510 : Pest of Horticultural and Plantation Crops 3(2+1)

THEORY

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.

Unit I

Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

Unit II

Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, drumstick, leafy vegetables, etc.

Unit III

Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine, etc.

Unit IV

Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.

PRACTICAL

- Collection and identification of important pests and their natural enemies on different crops;
- Study of life history of important insect pests and non-insect pests.

RESOURCES

Atwal AS and Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management*.

Kalyani Publishers, New Delhi.

Butani DK and Jotwani MG. 1984. *Insects and Vegetables*. Periodical Expert Book Agency, New Delhi.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Srivastava RP. 1997. *Mango Insect Pest Management*. International Book Distr., Dehra Dun.

Verma LR, Verma AK and Goutham DC. 2004. *Pest Management in Horticulture Crops: Principles and Practices*. Asiatech Publ., New Delhi.

STAT 502 Statistical Methods for Applied Sciences 4 (3+1)

THEORY

Unit I

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

Unit II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.

Unit III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

Unit IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

Unit V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

PRACTICAL

- Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative
- Binomial, Normal.
- Large sample tests, testing of hypothesis based on exact sampling distributions ~
- chi square, t and F .
- Confidence interval estimation and Correlation and regression analysis, fitting of
- Linear and Quadratic Model.
- Non-parametric tests. ANOVA: One way, Two Way, SRS.

RESOURCES

- Goon A.M, Gupta M.K and Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
- Hoel P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.
- Hogg R.V and Craig T.T. 1978. *Introduction to Mathematical Statistics*. Macmillan.
- Morrison D.F. 1976. *Multivariate Statistical Methods*. McGraw Hill.
- Hogg RV, McKean JW, Craig AT. 2012. *Introduction to Mathematical Statistics* 7th Edition.

- Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.
- Anderson TW. 2009. *An Introduction to Multivariate Statistical Analysis*, 3rd Ed. John Wiley

BIOCHEM 501 (BIOCHEM 512) Basic Biochemistry 4 (3+1)

Theory

Block 1: Introduction to Biochemistry

Unit 1: Scope and importance of biochemistry (1 Lecture)

Biochemistry as modern science and its various divisions, Scope and importance of biochemistry in agriculture and allied sciences.

Unit 2: Foundation of life (2 Lectures)

Fundamental principles governing life, supramolecular structures, significance of weak non covalent interactions in biology

Unit 3: Water (3 Lectures)

Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship.

Unit 4: Physical techniques for structure determination (2 Lectures)

General introduction to physical techniques for determination of structure of biopolymers.

Block 2: Structure And Function of Biomolecules

Unit 1: Biomolecules (10 Lectures)

Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Unit 2: Immunoglobulins and PR proteins (2 Lectures)

Structure, formation and different forms of immunoglobulins, PR proteins and their classification.

Unit 3: Plant secondary metabolites (3 Lectures)

Structure, classification and function of plant secondary metabolites.

Block 3: Metabolism – The Basics

Unit 1: Molecules aiding metabolism (2 Lectures)

Structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones:

animal and plants.

Unit 2: Thermodynamics –principles and energetic of life (2 Lectures)

Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Block 4: Catabolism and its Regulation

Unit 1: Catabolism of energy molecules (5 Lectures)

Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation.

Unit 2: ATP formation (3 Lectures)

Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic theory and proton motive force.

Block 5: Fundamentals of Molecular Biology and Genetic Engineering

Unit 1: Molecular biology processes (4 Lectures)

Overview of replication, transcription and translation.

Unit 2: Recombinant DNA technology (3 Lectures)

Restriction enzymes, DNA cloning, applications of cloning, transgenics.

Practicals

- Preparation of standard and buffer solutions
- Detection of carbohydrates, amino acids and proteins
- Extraction and estimation of sugars
- Extraction and estimation of amino acids
- Extraction and estimation of proteins

Estimation of acid value of fat/oil

- Estimation of peroxide value of fat/oil
- Estimation of saponification value in fats and oils
- Fatty acid composition in fat/oil by GC
- Estimation of DNA and RNA by spectroscopic methods
- Estimation of Ascorbic acid
- Separation of biomolecules by TLC and Paper chromatography
- Estimation of alpha amylase activity

- Qualitative tests for secondary plant metabolites.

RESOURCES

- Nelson DL and Cox MM. 2017. *Lehninger Principles of Biochemistry*. 7th edition. W. H. Freeman & Co Ltd
- Satyanarayana U and Chakrapani U. 2017. *Biochemistry*. 5th edition, Elsevier
- Moran LA, Horton HR, Scrimgeour KG and Perry MD. 2012. *Principles of Biochemistry*. 5th edition Pearson.
- Voet D and Voet JG. 2011. *Biochemistry*. 4th edition John Wiley.
- Pratt CW and Cornely K. 2014. *Essential Biochemistry*. 3rd Edition. Wiley
- Moorthy K. 2007. *Fundamentals of Biochemical Calculations*. 2nd edition. CRC Press
- Conn EE, Stumpf PK, Bruening G and Doi RH. 2006. *Outlines of Biochemistry*. 5th edition. Wiley.

STAT-511 Experimental Design 3 (2+1)

Theory

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques

in randomized block and Latin square designs; Transformations, Balanced

Incomplete Block Design, resolvable designs and their applications, Lattice design,

alpha design - concepts, randomization procedure, analysis and interpretation of

results. Response surfaces. Combined analysis.

VI. Practical

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law,

Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,

- Analysis with missing data,

- Split plot and strip plot designs.

Suggested Reading

- Cochran WG and Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

- Dean AM and Voss D. 1999. *Design and Analysis of Experiments*. Springer.

- Montgomery DC. 2012. *Design and Analysis of Experiments*, 8th Ed. John Wiley.

- Federer WT. 1985. *Experimental Designs*. MacMillan.

- Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.

- Nigam AK and Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.

- Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

- www.drs.icar.gov.in.

STAT-512 :Basic Sampling Techniques 3 (2+1)

Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample

survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

VI. Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

VII. Suggested Reading

- Cochran WG. 1977. *Sampling Techniques*. John Wiley.
- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication

MCA-501 : Computers Fundamentals and Programming 3 (2+1)

Theory

Unit I

Functional units of computer, I/O devices, primary and secondary memories. Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, Operator precedence, character representation; ASCII, Unicode.

Unit II

Programming Fundamentals with C - Algorithm, techniques of problem solving, flowcharting, stepwise refinement; Constants and variables; Data types: integer, character, real, data types; Arithmetic expressions, assignment statements, logical expressions. Control flow

Unit III

Arrays and structures. Pointers, dynamic memory allocations

Unit IV

Program Structures – functions, subroutines

Unit V

I/O operations, Program correctness; Debugging and testing of programs.

VI. Practical

- Conversion of different number types;
- Creation of flow chart, conversion of algorithm/flowchart to program;
- Mathematical operators, operator precedence;
- Sequence, control and iteration;
- Arrays and string processing;

- Matrix operations, Sorting, Pointers and File processing – Reading and writing

text files.

VII. Suggested Reading

- Balaguruswamy E. 2019. *Programming with ANSI C*. Tata McGraw Hill.
- Gottfried B. 2017. *Programming with C, Schaum Outline Series*. Tata McGraw Hill.
- Kanetkar Y. 1999. *Let Us C*. BPB Publ.

Malvino A.P. and Brown J.A.. 2017. *Digital Computer Electronics*. Tata McGrawHill.

- Mano M.M. 1999. *Digital Logic and Computer Design*. Prentice Hall of India.

BIOCHEM-505 : Techniques in Biochemistry 4 (2+2)

THEORY

Block 1: Separation Techniques

Principles and applications of separation techniques.

Unit 1: Chromatography techniques (4 Lectures)

Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity,

column & HPTLC, GC, HPLC and FPLC. **Unit 2: Electrophoretic technique (2 Lectures)**

General principles, paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

Unit 3: Hydrodynamic methods (2 Lectures)

Hydrodynamic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles.

Unit 4: Centrifugation (2 Lectures)

Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation.

Block 2: Spectroscopic Techniques

Unit 1: Spectrophotometry (3 Lectures)

Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

Unit 2: Mass spectroscopy (3 Lectures)

MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry in biochemistry.

Unit 3: Atomic absorption spectrophotometry (2 Lectures)

Principle, function and instrumentation of atomic absorption spectrophotometry.

Block 3. Microscopy

Unit 1: Microscopic techniques (2 Lectures)

Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit 1: Tracer technique (2 Lectures)

Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α , β and γ emitters, scintillation counters, γ -ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Unit 2: Imaging techniques (2 Lectures)

Principles and applications of phosphor imager, MRI and CT scan.

Unit 3: Immunochemical technique (2 Lectures)

Production of antibodies, immunoprecipitation, immunoblotting, immunoassays, RIA and ELISA.

Unit 4: Other techniques (2 Lectures)

Cryopreservation, polymerase chain reaction (PCR), FACS.

PRACTICALS

- Expression of concentration in terms of dilution, molarity, normality, percent expression
 - pH measurement and buffer preparation
 - Determination of absorption maxima of biomolecules
- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography
 - Separation and analysis of fatty acids/lipids by GC
 - Separation/estimation of biomolecules through HPLC and FPLC
 - Separation of proteins using ion exchange, gel filtration and affinity chromatography
 - Electrophoretic separation of proteins and nucleic acids
 - Centrifugation- differential and density gradient
 - $(\text{NH}_4)_2\text{SO}_4$ precipitation and dialysis
 - Use of radioisotopes in metabolic studies

- PCR
- ELISA
- Western blotting/ Dot blotting

Suggested Reading

- Boyer R. 2011. Biochemistry Laboratory: Modern Theory and Techniques 2nd Edition. Pearson
- Hofmann A and Clokie S. 2010. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press.
- Sawhney SK and Singh R. 2000. Introductory Practical Biochemistry. 2nd Ed. Narosa
- Katoch R. 2011. Analytical Techniques in Biochemistry and Molecular Biology. Springer
- Boyer R. 2009. Modern Experimental Biochemistry. Fifth impression. Pearson
- Lottspeich F and Engels JW. (Eds). 2018. Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH
- Wilson K and Walker J. 2010. Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press

STAT-522 : Data Analysis Using Statistical Packages 3 (2+1)

Theory

Unit I

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit II

Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.

Unit III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

Unit IV

Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

Unit V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

VI. Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample t -test, two sample t -test, paired t -test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components;
- Linear regression, Multiple regression, Regression plots;
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

VII. Suggested Reading

- Anderson C.W. and Loynes R.M. 1987. *The Teaching of Practical Statistics*. John Wiley.
- Atkinson A.C. 1985. *Plots Transformations and Regression*. Oxford University Press.
- Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmont, California.
- Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
- Cleveland W.S. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
- Erickson B.H. and Nosanchuk T.A. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
- Snell E.J. and Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman and Hall.

- Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
- Velleman PF and Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
- Weisberg S. 1985. *Applied Linear Regression*. John Wiley.

MCA 512 :Information Technology in Agriculture 2+0

Theory

Unit I

Introduction to Computers, Anatomy of computer, Operating Systems, definition and types, Applications of MS Office for document creation & Editing, Data presentation, interpretation and graph creation, statistical analysis, mathematical expressions,

Unit II

Database, concepts and types, uses of DBMS in Agriculture, World Wide Web (WWW): Concepts and components, Introduction to computer programming languages, concepts and standard input/output operations. e-Agriculture, concepts and applications,

Unit III

Use of ICT in Agriculture, Computer Models for understanding plant processes. IT application for computation of water and nutrient requirement of crops, Computer controlled devices (automated systems) for Agri-input management, Smartphone Apps in Agriculture for farm advises, market price, postharvest management etc.,

Unit IV

Geospatial technology for generating valuable agri-information. Decision support systems, concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting Farm decisions, Preparation of contingent crop-planning using IT tools.

VI. Suggested Reading

- Vanitha G. 2011. *Agro-informatics*
- <http://www.agrimoon.com>
- <http://www.agriinfo.in>
- <http://www.eagri.org>
- <http://www.agriglance.com>
- <http://agritech.tnau.ac.in>

MCA-511 : Introduction to Communication Technologies, Computer Networking and Internet 2 (1+1)

Theory

Unit I

Networking fundamentals, types of networking, network topology; Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP), Internet Protocol v4 & v6. Network infrastructure and Security-switches, routers, firewall, intranet, internet, Virtual Private Network

Unit II

World Wide Web (www), working with Internet; Web pages, web sites, web servers; Web Applications.

Unit III

Hyper Text Markup Language (HTML), DHTML, web based application development. Static websites, dynamic websites. Client Side processing – scripting

languages, JQuery. Server Side processing ASP.NET/JSP

VI. Practical

- Network and mail configuration;
- Using Network Services;
- Browsing of Internet;
- Creation of web pages;
- Creation of websites using HTML and scripting languages.

VII. Suggested Reading

- Cox V, Wermers L and Reding E.E. 2006. *HTML Illustrated Complete*. 3rd Ed. Course Technology.
- Niederst J. 2001. *Web Design in a Nutshell*. O'Reilly Media.
- Tanenbaum A.S. 2003. Computer Networks. *Prentice Hall of I*

Revised PDC & Migration Certificate

Roll No. Serial No.
Enrolment No.

AGRICULTURE UNIVERSITY
KOTA (RAJASTHAN) INDIA



PROVISIONAL DEGREE CERTIFICATE
(GRADUATE)

Certified that
Son/Daughter of Mr.....(Father)
and Mrs.....(Mother)
appeared at the final year BACHELOR OF SCIENCE (HONOURS)
AGRICULTURE of Four Year Integrated Course examination of the university in
the Academic Session 2020-21 from SCRS GOVT COLLEGE SAWAI
MADHOPUR securing an Overall Grade Point Average of out of 10 and
passed the same with division.

KOTA
DATE..... Controller of Examinations

Serial No. Registration No.
Enrolment No. :

AGRICULTURE UNIVERSITY
KOTA (Rajasthan) INDIA



PROVISIONAL DEGREE CERTIFICATE
(POST GRADUATE)

Certified that
Son/Daughter of Mr..... (Father)
and Mrs.....(Mother)
appeared at the
Examination of the University in the month of
from.....
securing an Overall Grade Point Average of out of 10 and passed the same
with division.
Date of completion of degree

KOTA
Date..... Controller of Examinations

Note: The date of submission of bound thesis is considered as the date of completion of degree.

Serial No. Registration No.
Enrolment No.

AGRICULTURE UNIVERSITY
KOTA (Rajasthan) INDIA



PROVISIONAL DEGREE CERTIFICATE
(DOCTOR OF PHILOSOPHY)

Certified that
Son/Daughter of Mr.....(Father)
and Mrs.....(Mother)
appeared at the
Examination of the University in the month of
from.....
securing an Overall Grade Point Average of out of 10 and passed the same.
Date of completion of degree.....

KOTA
Date..... Controller of Examinations

Note: The date of submission of bound thesis is considered as the date of completion of degree.

Serial No. of 20....

AGRICULTURE UNIVERSITY
KOTA (RAJASTHAN) INDIA



MIGRATION CERTIFICATE

This university has no objection to migration of
.....
Son/Daughter of Mr.....(Father)
and Mrs.....(Mother)
to another University/Board. His/Her Enrolment No. is.....

KOTA
DATE..... Controller of Examinations

The PDC and Migration Certificate will be printed in duplicate on A-4 size thicker and off-water coloured paper.

Qualifications/Eligibility for Direct Recruitment for Teaching posts including SMS

(A) Professor / Chief Scientist or equivalent

1. Essential qualifications:

1.1 An eminent scholar having a Ph.D. degree in the concerned/ relevant discipline, and published work of high quality, actively engaged in research with evidence of published work with, a minimum of **ten** research publications in peer reviewed journals.

1.2 A minimum of 10 years' teaching/ research/ extension education experience on the post not less than Assistant Professor or equivalent of which at least 2 years' experience should be on the post of Associate Professor at an AGP of Rs. 9000/- (Academic level 13 A) or in an equivalent position in a University/ College and/ or Accredited National or International Research Institution.

1.3 A minimum score as stipulated in API based PBAS as set out by University.

2. Desirable: Contribution to education/ research/ extension innovation, design of new curricula and courses and technology- mediated teaching learning process.

(B) Associate Professor

1. Essential Qualifications:

1.1 A good academic record with Doctoral degree in the concerned / relevant subject.

1.2 A Master's Degree with at least 55% marks (or an equivalent grade in a point-scale, wherever the grading system is followed).

1.3 A minimum of 8 years teaching/ research/ extension education experience in the relevant subject as Assistant Professor/Scientist/ Lecturer/ Extension Specialist or in an equivalent position in the minimum pay of Academic level-10 or pay band -3 of Rs.15600-39100 with Grade Pay of Rs. 6000/-, Rs. 7000/- and Rs. 8000/- in a University/ College and/ or Accredited National or International Research Institution (excluding the period spent in Ph.D. research subject to maximum of 3 years) having made contribution to research/ teaching/ extension as evidenced by published work/innovations and impact with a minimum of **seven** research publications in peer reviewed journals.

1.4 A minimum score as stipulated in API based PBAS as set out by University.

Note: A good academic record means at least an average of 55% marks in the examinations preceding to Master's degree with at least 55 % marks in graduation and any one of the Secondary, Higher Secondary/ Senior Secondary or equivalent grades in the point scale wherever grading system is followed without including grace marks and / or rounding off to make it 55% or 50 % as the case may be. A relaxation of 5 % will be given in average marks only to the SC, ST, OBC (Non- creamy layer), MBC (Non- creamy layer) and differentially -abled (Divyangjan) candidates. The relaxation is only for average marks only; separately 5 % relaxation shall not be given at Secondary, Higher Secondary/ Senior Secondary and graduation level only.

(C) Senior Scientist and Head

1. Essential Qualifications:

1.1 Doctoral degree in the relevant subject including relevant basic sciences with 08 years' experience in the relevant subject as Scientist/ Lecturer/ Extension Specialist or in an equivalent position in the minimum pay band -3 of Rs.15600-39100 with Grade Pay of Rs. 5400/ Rs. 6000/ Rs. 7000/ Rs. 8000/- (excluding the period

spent in Ph.D. research subject to maximum of 3 years) having made contribution to research/ teaching/ extension as evidenced by published work/innovations and impact.

1.3 A minimum score as stipulated in API based PBAS as set out by University.

Desirable: Specialization in implementing extension education programme

(D) Assistant Professor (other than Computer Science Engineering)

1. Essential Qualifications:

1.1 A Master's degree in the concerned/ relevant subject with at least 55% marks (or an equivalent grade/ OGPA/CGPA in a point scale wherever grading system is followed) from Indian University(s), or an equivalent degree from a recognized foreign University. A relaxation of 5% shall be given to SC, ST, OBC (Non- creamy layer), MBC (Non- creamy layer) and differentially- abled (Divyangjan) candidates.

1.2 For the candidates having Master's degree, NET shall remain compulsory along with one publication in NAAS (National Academy of Agricultural Sciences, New Delhi) rated refereed journal for recruitment to the post of Assistant Professor and equivalent in the disciplines in which NET is conducted. Essentiality of NET can be waived off for the candidates holding Ph.D. degree provided, it has been done with course work as prescribed by the UGC Regulations, 2009 (and also as per ICAR letter No. 23 (46) /2010-EQR (Edn.) dated 26th December, 2011, issued by ADG (EQR), and the candidate has at least **Two full length publications having a NAAS rating not less than 4.0 on the last date of submission of application.** Those candidates with Ph.D. degree without course work will not qualify for NET exemption.

1.3 Further, the award of degrees to candidate registered for the M.Phil / Ph.D programme prior to July 11, 2009, shall be governed by the provisions of the then existing Ordinances/By laws/Regulations of the Institution awarding the degrees and the Ph.D candidates shall be exempted from the requirement of the minimum eligibility condition of NET/SLET/SET for recruitment and appointment of Assistant Professor or equivalent positions in Universities / Colleges / Institutions subject to the fulfilment of the following conditions:

- i. Ph. D. degree of the candidate awarded in regular mode only.
- ii. Evaluation of the Ph. D. thesis by atleast two external examiners.
- iii. Candidate had published two research papers out of which at least one in a refereed journal from out of his/her Ph.D. work.
- iv. The candidate had presented two papers in seminars / conferences from out of his/her Ph.D. work
- v. Open Ph.D. viva-voce of the candidate had been conducted.

Note: i. to v. as above are to be certified by the Registrar/ COE/ Competent Authority of degree awarding University / Institution.

1.4 NET shall not be required for such Master's programmes in the discipline for which NET is not conducted.

1.5 A minimum score as stipulated in API based PBAS as set out by University.

2. Desirable: Ph. D. degree in relevant subject.

(E) Assistant Professor (Computer Science Engineering)

1. Essential Qualifications:

1.1 B.E. / B. Tech./ B.S. and M.E. / M. Tech./ M.S. or Integrated M.Tech. in relevant branch with first class or equivalent in any one of the degrees.

1.2 A minimum score as stipulated in API based PBAS as set out by University.

2. Desirable:

- 2.1 Ph. D. in relevant discipline
- 2.2 Teaching, research, industrial and / or professional experience in a reputed organization;
- 2.3 Paper presented at conference and/ or in refereed journals.

(F) Assistant Librarian

1. Essential Qualifications:

- 1.1 Master's degree in Library Science / Information Science/ Documentation Science or an equivalent degree with at least 55% marks (or an equivalent grade/OGPA in a point scale wherever grading system is followed) from an Indian University, or an equivalent degree from a recognized foreign University. A relaxation of 5% shall be given to SC, ST, OBC (Non- creamy layer), MBC (Non-creamy layer) and differentially- abled (Divyangjan) candidates.
- 1.2 Qualified the National Eligibility test (NET) in **Library Sciences** conducted for the purpose by the UGC or any other agency approved by the UGC.
- 1.3 Essentiality of NET can be waived off for the candidates holding Ph.D. degree provided, it has been done with course work as prescribed by the UGC Regulations, 2009 (and also as per ICAR letter No. 23 (46) /2010-EQR (Edn.) dated 26th December, 2011, issued by ADG (EQR), and the candidate has at least Two full length publications having a NAAS rating not less than 4.0 on the last date of submission of application. Those candidates with Ph.D. degree without course work will not qualify for NET exemption.
- 1.5 Further, the award of degrees to candidate registered for the M.Phil / Ph.D programme prior to July 11, 2009, shall be governed by the provisions of the then existing Ordinances/By laws/Regulations of the Institution awarding the degrees and the Ph.D candidates shall be exempted from the requirement of the minimum eligibility condition of NET/SLET/SET for recruitment and appointment of Assistant Professor or equivalent positions in Universities / Colleges / Institutions subject to the fulfilment of the following conditions:
 - i. Ph. D. degree of the candidate awarded in regular mode only
 - ii. Evaluation of the Ph. D. thesis by atleast two external examiners
 - iii. Candidate had published two research papers out of which atleast one in a refereed journal from out of his/her Ph.D. work
 - iv. The candidate had presented two papers in seminars / conferences from out of his/her Ph.D. work
 - v. Open Ph.D. viva-voce of the candidate had been conducted.
- Note:** i. to v. as above are to be certified by the COE or Competent Authority of degree awarding University / Institution.
- 1.6 NET/ SLET/ SET shall also not be required for candidates in such Master's Programmes for which NET/ SLET/ SET is not conducted by the UGC/ CSIR or similar test accredited by the UGC like SLET/ SET.
- 1.6 A minimum score as stipulated in API based PBAS as set out by University. Desirable: Ph.D. in relevant discipline.

2. Desirable: knowledge of computerization of a library.

(G) Subject Matter Specialist

1. Essential Qualifications:

- 1.1 Master's degree in the concerned/ relevant subject
- 1.2 A minimum score as stipulated in API based PBAS as set out by University.

2. Desirable: Doctoral degree in relevant subject.

Concerned/ Relevant subjects prescribed for the various discipline of teaching posts including SMS are as under:

S.No.	Discipline of the post	Concerned/ Relevant subject
1.	Agricultural Engineering	Master's degree (M.E./ M.Tech./ M.S.) in Agricultural Engineering with specialization in Farm Machinery and Power engineering/ Renewable Energy engineering/ Irrigation and drainage Engineering/ Soil and Water Conservation Engineering
2.	Agriculture Economics	Master's degree in Agriculture with specialization in Agriculture Economics/ Dairy economics/ Economics with specialization in Agriculture
3.	Agriculture Statistics	Master's degree in Agriculture Statistics/ Statistics with specialization in Agriculture Statistics
4.	Agronomy	Master's degree in Agriculture with specialization in Agronomy
5.	Animal Husbandry	Masters' degree in Agriculture with specialization in Live Stock Production and Management/ Animal Production/ Animal husbandry & Dairying/ M.V.S.C in Live Stock Production & management
6.	Biochemistry	Master's degree in Plant Biochemistry/ Agricultural Biochemistry
7.	Computer Science & Engineering	Master's degree (M.E./ M.Tech./ M.S.) in Computer Science Engineering/ Computer Science/ Computer Application/ Computer Engineering
8.	Entomology	Master's degree in Agriculture with specialization in Entomology/ Agricultural Entomology
9.	Environmental Science	Master's degree in Agriculture with specialization in Environmental Science/ Environmental Science/Agroforestry/ Agriculture Physics/ Master's degree in Forestry with specialization in Environmental Management
10.	Extension Education	Master's degree in Agriculture with specialization in Extension Education/ Agricultural Extension/ Agricultural Extension & Communication
11.	Floriculture & Landscape Architecture	Master's degree in Floriculture & Landscape Architecture/ Floriculture & Landscaping/ Floriculture/ Horticulture with specialization in Floriculture & Landscape Architecture/ Floriculture & Landscaping/ Floriculture
12.	Food Science	Master's degree in Food Science/ Food Technology/ Food Processing Technology/ Food Science and Technology/ Food Science & Post-Harvest Technology/ Food Technology & Management.
13.	Forest Biology & Tree improvement	Master's degree in Forestry with specialization in Forest biology and tree improvement/ Tree improvement/ Forest Biotechnology/ Forest Genetic resources
14.	Forest Products Utilization	Master's degree in Forestry with specialization in Forest Products Utilization/ Forest Products and Utilization/ Wood Science & Technology/ Medicinal & Aromatic Plants or Master's degree in Wood Science & Technology
15.	Fruit Science	Master's degree in Fruit Science/ Pomology/ Horticulture with specialization in Fruit Sciences
16.	Genetics & Plant Breeding	Master's degree in Agriculture with specialization in Plant Breeding/ Genetics/ Genetics and Plant Breeding / Plant Breeding & Genetics/ Plant Genetic Resources.
17.	Horticulture	Master's degree in Agriculture with specialization in Horticulture or Master's degree in Horticulture with Specialization in Fruit Science/ Vegetable Science/ Floriculture and Landscaping/ Post-Harvest Technology
18.	Microbiology	Master's degree in Agricultural Microbiology or Master's degree in Science with specialization in Agricultural

		Microbiology.
19.	Nematology	Master's degree in Agriculture with specialization in Nematology
20.	Plant Pathology	Master's degree in Agriculture with specialization in Mycology and Plant Pathology/ Plant Pathology
21.	Plant Physiology	Master's degree in Agriculture/ Botany with specialization in Plant Physiology
22.	Plant Protection	Master's degree in Agriculture with specialization in Entomology/ Agricultural Entomology /Mycology and Plant Pathology/ Plant Pathology or Master's degree in Agriculture with specialization in Nematology
23.	Post-Harvest Technology	Master's degree in Post-Harvest Technology/ Food Science & Post-Harvest Technology/ Horticulture with specialization in Post-Harvest Technology
24.	Seed Technology	Master's degree in Agriculture with specialization in Seed Science/ Seed Technology/ Seed Science and Technology.
25.	Silviculture & Agroforestry	Master's degree in Forestry with specialization in Silviculture & Agroforestry/ Silviculture/ Agroforestry/ Plantation Technology
26.	Soil Science	Master's degree in Agriculture with specialization in Soil Science/ Soil Science & Agricultural Chemistry
27.	Vegetable Science	Master's degree in Olericulture/ Vegetable Sciences/ Horticulture with specialization in Vegetable Sciences
28.	Wild Life Sciences	Master's degree in Wild Life Sciences/ Wild Life Management or Master's degree in Forestry/ Zoology with Specialization in Wild life Sciences/ Wild Life Management

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR DIRECT SELECTION ON THE
POST OF ASSISTANT PROFESSOR/ ASSISTANT LIBRARIAN OR EQUIVALENT POSTS

Name:

Subject:.....

S. No	Attributes	Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic background	51			
1.1	Secondary school examination (Percentage of marks x 0.02)	02			
1.2	Hr. Sec.(XI)/Sr. Secondary school (XII or 10+2 level) examination or equivalent (Percentage of marks x 0.03)	03			
1.3	Bachelor's degree (Percentage of marks x 0.17)	17			
1.4	Master's degree (Percentage of marks x 0.21)	21			
1.5	Ph.D. degree (Percentage of marks x 0.08) Candidate having Ph.D. degree without course work will be awarded 4 marks only	08			
Note: (a) If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily attached with the application. However, if the board/ university does not declare equivalent percentage in case of 4 point scale, it shall be determined by the following formula: $Y = (50 - 10X) + 5X^2$, where Y is Equivalent Percentage and X is OGPA obtained in 4 point scale. In case of numerical grading system on 10 point scale the percentage shall be calculated as OGPA multiplied by 10. (b) If the University does not give an overall percentage/ grade point of all years of the degree, then the average of all years/ semesters shall be taken for computation of OGPA or Equivalent percentage.					
2.	Awards & recognitions	07			
2.1	Jawaharlal Nehru award of ICAR for best Ph.D. thesis = 2 marks				
2.2	1.5 marks for Best thesis award at National level and 1.0 marks at University level (If the candidate gets more than one award for the same achievement / thesis; the highest award will be considered for allotting the marks)				
2.3	Chancellor's Gold Medal award = 1.5 marks				
2.4	University gold medal = 1.0 mark each for award at UG and PG level in academics	02			
2.5	JRF/SRF through National Level Exam conducted by UGC/ICAR/CSIR or GATE = 2 marks each	04			
2.6	International/National award / awards from ICAR/ Govt Institutions = 1.0 mark each	02			
2.7	National level award from Professional Society/Academies = 0.5 mark each	02			
3.	Service Experience	04			
3.1	Each completed year of service experience in Agricultural Research/Extension/Teaching after post-graduation in State and Central Govt./State and Central Universities/ICAR organizations= 1.00 mark				
4.	Participation in seminar/ symposium/ conference/ trainings etc.	03			
4.1	Oral/ poster presentation in National or International seminar/ Symposium/ Conference/ workshop attended in India = 0.5	01			

		mark each				
	4.2	Participation in seminar/ symposium/ conference/ workshop Abroad = 1.0 mark each				
	4.3	Participation in training programme of one week duration or more outside parent University/ Institution in subject area = 1 mark each	02			
5.	Publications		10			
	5.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark for second author and 0.5 mark for other authors				
	5.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for second author and 0.25 mark for other authors				
	5.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for second author and 0.10 mark for other authors				
	5.4	- Each book published with ISBN no. having minimum 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark - Each edited book having ISBN/proceedings of conference etc. having more than 125 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark				
	5.5	Book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in journals not included in (5.1) to (5.3) categories =1st author, 0.50 mark and co-authors, 0.25mark	03			
	5.6	Each published popular article/ folder/ leaflet/ Abstract/ Extended summary= 0.25 for 1 st author and 0.10 for co- authors	02			
	5.7	Each radio talk / T V talk = 0.1 mark	01			
	Note: (a) All the publications should have been published as on the last date prescribed for submission of application. (b) Latest rating declared by NAAS/ UGC listed journals will be considered.					
6.	Co-curricular and Extra- curricular activities		05			
	(a)	Certificate of winner/ runner up at All India Inter University Games & Sports meet/ Youth festivals Participation in State/National level games organized by Govt. recognized bodies/ NCC `C` certificate = 1.0 mark each				
	(b)	Certificate of participation in All India Inter University Games & Sports meet/ Youth festivals/ Republic day parade = 0.5 marks each				
	(c)	NSS certificate/ NCC`B` certificate/ army attachment camp/ participation in Zonal level Inter- University games & sports meet and youth festival = 0.25 marks each				
7.	Total S.No.1-6		80			
8.	Interview		20			

Grand TOTAL (S.No. 7+8)		100			
<u>Note:</u> 1. The candidates securing minimum 50% marks of the total score shall be eligible for interview. The candidates must secure 50% marks separately in interview for selection. 2. The final selection shall be made based on the total marks obtained in score card and interview. 3. Where the number of applications received is large in number and it is not convenient or possible for the University to interview to all those candidates, the University may restrict the number of candidates by screening of applications based on Score card or the university may fix criteria to shortlist the candidates to be called for interview according to number of posts and category. 4. The number of candidates to be called for interview shall be in the ratio of 1:8. <i>If there is tie of score for last candidate, all candidates securing equal marks will be called for interview.</i>					

Signature of candidate with date

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR DIRECT SELECTION ON THE
POST OF ASSOCIATE PROFESSOR/ SENIOR SCIENTIST & HEAD OR EQUIVALENT POSTS

Name:

Subject:.....

S. No	Attributes	Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic Background	16			
1.2	Bachelor's degree (Percentage of marks x 0.03)	03			
1.3	Master's degree (Percentage of marks x 0.05)	05			
1.4	Ph.D. degree (Percentage of marks x 0.07) Candidates having Ph.D. degree without course work will be awarded 3.5 marks only.	07			
1.5	Post-doctoral fellow (0.5 mark for each completed 6 months)	01			
Note: (a) If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily attached with the application. However, if the board/ university does not declare equivalent percentage in case of 4 point scale, it shall be determined by the following formula: $Y = (50 - 10X) + 5X^2$, where Y is Equivalent Percentage and X is OGPA obtained in 4 point scale. In case of numerical grading system on 10 point scale the percentage shall be calculated as OGPA multiplied by 10. (b) If the University does not give an overall percentage/ grade point of all years of the degree, then the average of all years/ semesters shall be taken for computation of OGPA or Equivalent percentage.					
2.	Academic Awards & recognition	04			
2.1	Jawaharlal Nehru award for Ph.D. thesis = 02 marks	02			
2.2	University gold medal = 1.0 mark each for award at UG and PG level in academics	02			
2.3	Best thesis award = 01 mark	01			
2.4	SRF through National Level Exam conducted by UGC/ICAR/CSIR = 1 marks	01			
3.	Awards & recognition during the period of Assistant Professor or equivalent	04			
3.1	Individual/ team award by Central Govt. organizations such as ICAR, CSIR, UGC, DBT, DST, National Institutes, FAO = 1 mark each	02			
3.2	Individual/ team award by state government or ICAR/ UGC recognized Universities = 0.5 mark each	02			
3.3	Fellow/ Award/ recognition by recognized national academies/ Professional societies = 0.5 mark each	02			
Note: If the award is received by a team, the team leader will get full mark and co-leaders will be awarded half mark. If a candidate gets more awards for the same achievement, the highest award will be considered for allotment of marks.					
4.	Service Experience	04			
4.1	Regularly selected Assistant Professor/ Scientist or equivalent post in State and Central Govt./State and Central Universities/ICAR organizations which should be over and above the prescribed period for particular post = 01 mark for each year				
5.	Teaching / Research / Extension attainments	20			

	(during the period of Assistant Professor or equivalent)					
5.1	No. of UG/ PG courses taught = 0.50 marks for each course per semester (If courses are taught jointly, the proportionate marks will be considered.)	15				
5.2	Ph.D. thesis, Master's thesis guided as major advisor = 1.0 mark and 0.5 mark , each, respectively and 0.5 mark and 0.25 mark each, respectively as member of advisory committee.					
5.3	No. of experiments conducted (0.1 marks for each experiment as sole researcher)	05				
5.4	Each patent granted/variety developed and released at National Level = Team leader, 2.0 marks and Associates 0.5 mark , Variety developed and released at state level = Team leader, 1.0 marks and Associates 0.25 mark					
5.5	Each technology developed and included in the package of practices = 0.5 mark for team leader and 0.25 mark for associates	05				
5.6	Submission and approval of each project costing Rs. 20.0 lacs or more =Principal Investigator 2.0 marks and Co-PI / Associate Investigator 1.0 marks					
5.7	Testing of each project or project allotted by University/Organization costing Rs.4.0 lacs or more = Principal Investigator, 0.5 mark and Co-PI / Associate Investigator, 0.25 mark	04				
5.8	Each training course of 2 to 6 days duration conducted as organizer for trainers or officers /stake holders/farmers etc.= 0.25 mark each,.	06				
5.9	Each training course of 7 to 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 0.50 mark					
5.10	Each training course of more than 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 1.0 mark					
5.11	Each 100 FLDs/other demonstrations/ OFTs conducted as Major contributor = 0.50 mark and Co-contributors = 0.25	05				
5.12	Organization of <i>kisan mela</i> at State/National level = 2.0 mark each and at District /Division level= 1.0 mark each	02				
5.13	Lecture delivered in trainings / field days / <i>kisan mela</i> etc. = 0.10 mark each,	02				
5.14	Each success story published/ mobile app developed = 0.5 mark for major contributor and 0.25 mark for associated contributor	02				
5.15	Each summer / winter school / refresher course etc. for more than 14 days duration conducted as organizer = 2.5 mark and co-organizer = 1.0 mark					
5.16	Each National/International symposium/ seminar/ conference /workshop/ group meeting organized as organizer= 1.0 mark and Co-organizer = 0.50 mark					
5.17	Each lecture delivered as resource person /	02				

		Invited lecture in summer / winter school / refresher course/ symposium /seminar/ conference etc. = 0.50 mark each,				
	5.18	Each TV/Radio talk =0.1 mark each,	01			
	5.19	Full time duties of continuous nature other than Teaching / Research / Extension as assigned by the University / Competent authority such as COE/ University DDO/ OSD/ Deputy/ Assistant Registrar, Deputy/ Assistant Director, O/I of stations or any other to be decided by screening / scrutiny committee = 2.0 marks for each year				
	5.20	Assignments for preparation of annual reports/ self-study report, Research/ Extension Highlights, Vision document, periodicals/ newsletter or any other major documents at University/ Directorate/ College level = 0.5 mark each as major contributor, 0.25 mark as associate contributor.	02			
6.	Summer/ winter school, refresher course/ trainings/ seminar/ symposium attended		05			
	6.1	Special Training attended in area of specialization from abroad of 3 months or more= 2.0 marks each and 1.00 mark each for training less than 3 months/ seminar/ symposium/ conference attended in abroad				
	6.2	Methodology course/ training attended in India of more than 20 days = 0.5 mark each, 7-20 days = 0.25 mark each and 2-6 days = 0.1 mark each	2.0			
7.	Publications: (during the period of Assistant Professor or equivalent)		15			
	7.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark for second author and 0.5 mark for other authors				
	7.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for second author and 0.25 mark for other authors				
	7.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for second author and 0.10 mark for other authors				
	7.4	- Each book published with ISBN no. having minimum 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark - Each edited book having ISBN/proceedings of conference etc. having more than 125 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark				
	7.5	Book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in				

		journals not included in (7.1) to (7.3) categories =1st author, 0.5 mark and co-authors, 0.25mark				
	7.6	Each short note / communication published in NAAS rated journal = 1 st author, 0.5 and co-authors, 0.25 mark				
	7.7	Each abstract published in seminar /symposium /conference/short note papers published in Non- NAAS journals = 1 st author, 0.25 mark and co-authors, 0.10 mark,	02			
	7.8	Each popular article published / folder/ leaflet= 0.25 for 1 st author and 0.10 for co-authors	03			
	Note: (a) All the publications should have been published as on the last date prescribed for submission of application. (b) Latest rating declared by NAAS/ UGC listed journals will be considered.					
8.	Additional duties / Institution building: (during the period of Assistant Professor or equivalent)		07			
	8.1	Additional duties of continuous nature as Farm Incharge, Chief hostel Warden, Hostel warden, DDO of Units, ADSW, Incharge, NSS/ NCC/ Games & sports/ placement Cell / website/ Establishment / pool/ accounts/ technical cell/ Central Store/ Students section/ Academic/ Asstt. Examination Suptd. / Library/ Central lab/ Land scaping /Nodal officers etc. or other additional duties of continuous nature assigned by the University/Competent authority, to be decided by screening / scrutiny committee. = 1.0 mark for each year				
9.	Total (S.No.1 to 8)		75			
10.	Interview:		25			
Grand Total (S.No. 9 +10)			100			

Note:

1. The candidates securing minimum 50% marks of the total score shall be eligible for interview. The candidates must secure 50% marks separately in interview for selection.
2. The final selection shall be made based on the total marks obtained in score card and interview.
3. Where the number of applications received is large in number and it is not convenient or possible for the University to interview to all those candidates, the University may restrict the number of candidates by screening of applications based on Score card or the university may fix criteria to shortlist the candidates to be called for interview according to number of posts and category.

Signature of candidate with date

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR DIRECT SELECTION ON THE
POST OF PROFESSOR/ CHIEF SCIENTIST OR EQUIVALENT POSTS

Name:

Subject:.....

S. No	Attributes	Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic Background	14			
1.2	Bachelor's degree (Percentage of marks x 0.02)	02			
1.3	Master's degree (Percentage of marks x 0.04)	04			
1.4	Ph.D. degree (Percentage of marks x 0.07) Candidates having Ph.D. degree without course work will be awarded 3.5 marks only.	07			
1.5	Post-doctoral fellow (0.5 mark for each completed 6 months)	01			
Note: (a) If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily attached with the application. However, if the board/ university does not declare equivalent percentage in case of 4 point scale, it shall be determined by the following formula: $Y = (50 - 10X) + 5X^2$, where Y is Equivalent Percentage and X is OGPA obtained in 4 point scale. In case of numerical grading system on 10 point scale the percentage shall be calculated as OGPA multiplied by 10. (b) If the University does not give an overall percentage/ grade point of all years of the degree, then the average of all years/ semesters shall be taken for computation of OGPA or Equivalent percentage.					
2.	Academic Awards & recognition	04			
2.1	Jawaharlal Nehru award for Ph.D. thesis = 02 marks	02			
2.2	University gold medal = 1.0 mark each for award at UG and PG level in academics	02			
2.3	Best thesis award = 01 mark	01			
2.4	SRF through National Level Exam conducted by UGC/ICAR/CSIR = 1 marks	01			
3.	Awards & recognition during the period of Assistant Professor/ Associate Professor or equivalent	04			
3.1	Individual/ team award by Central Govt. organizations such as ICAR, CSIR, UGC, DBT, DST, National Institutes, FAO = 1 mark each	02			
3.2	Individual/ team award by state government or ICAR/ UGC recognized Universities = 0.5 mark each	02			
3.3	Fellow/ Award/ recognition by recognized national academies/ Professional societies = 0.5 mark each	02			
Note: If the award is received by a team, the team leader will get full mark and co-leaders will be awarded half mark . If a candidate gets more awards for the same achievement, the highest award will be considered for allotment of marks.					
4.	Service Experience	04			
4.1	Associate Professor or equivalent in State and Central Govt./State and Central Universities/ICAR organizations which should be over and above the prescribed period for particular post = 02 mark for each year				
5.	Teaching / Research / Extension attainments (during the period of Associate Professor or equivalent)	15			
5.1	No. of UG/ PG courses taught = 1.0 marks for each course per semester (If courses are taught jointly, the proportionate marks will be considered.)				
5.2	Ph.D. thesis, Master's thesis guided as major advisor = 2.0 mark and 0.5 mark , each, respectively and 1.0 mark and 0.25 mark each, respectively as member of				

		advisory committee.				
	5.3	No. of experiments conducted (0.25 marks for each experiment as sole researcher)	05			
	5.4	Each patent granted/variety developed and released at National Level = Team leader, 4.0 marks and Associates 1.0 mark , Variety developed and released at state level= Team leader, 2.0 marks and Associates 0.50 mark				
	5.5	Each technology developed and included in the package of practices = 3.0 mark for team leader and 1.50 mark for associates				
	5.6	Submission and approval of each project costing Rs. 50.0 lacs or more =Principal Investigator 4.0 marks and Co-PI / Associate Investigator 1.5 marks				
	5.7	Testing of each project or project allotted by University/Organization costing Rs. 4.0 lacs or more = Principal Investigator, 1.0 mark and Co-PI / Associate Investigator, 0.50 mark				
	5.8	Each training course of 2 to 6 days duration conducted as organizer for trainers or officers /stake holders/farmers etc.= 0.50 mark each,.	05			
	5.9	Each training course of 7 to 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 1.0 mark				
	5.10	Each training course of more than 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 2.5 mark				
	5.11	Each 50 successful FLDs/ other demonstrations/OFTs conducted as Major contributor = 0.5 mark and Co-contributors = 0.25	04			
	5.12	Organization of <i>kisan mela</i> at State/National level = 2.0 mark each and at District /Division level= 1.0 mark each	02			
	5.13	Lecture delivered in trainings / field days / <i>kisan mela</i> etc. = 0.25 mark each,	05			
	5.14	Each success story published/ mobile app developed = 1.0 mark for major contributor and 0.50 mark for associated contributor	03			
	5.15	Each summer / winter school / refresher course etc. for more than 14 days duration conducted as organizer = 2.5mark and co-organizer = 1.0 mark				
	5.16	Each National/International symposium/ seminar/ conference /workshop/ group meeting organized as organizer = 1.0 mark and Co-organizer = 0.50 mark				
	5.17	Each lecture delivered as resource person / Invited lecture in summer / winter school / refresher course/ symposium /seminar/ conference etc. = 1.0 mark each,	05			
	5.18	Each TV/Radio talk = 0.5 mark each ,	02			
	5.19	Full time duties of continuous nature other than Teaching / Research / Extension as assigned by the University / Competent authority such as COE/ University DDO/ OSD/ Deputy/ Assistant Registrar, Deputy/ Assistant Director, O/I of stations or any other to be decided by screening / scrutiny committee = 2.0 marks for each year				
	5.20	Assignments for preparation of annual reports/ self-study report, Research/ Extension Highlights, Vision document, periodicals/ newsletter or any other major documents at University/ Directorate/ College level = 0.5 mark each as major contributor, 0.25 mark as associate contributor.	03			
6.	Summer/ winter school, refresher course/ trainings/		02			

	seminar/ symposium attended				
6.1	Special Training attended in area of specialization from abroad of 3 months or more= 3.0 marks each and 1.5 mark each for training less than 3 months/ seminar/ symposium/ conference attended in abroad				
6.2	Methodology course/ training attended in India of more than 20 days = 1.0 mark each, 7-20 days = 0.50 mark each and 2-6 days = 0.25 mark each				
7.	Publications: (since joining as Assistant Professor or equivalent)	24			
7.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark for second author and 0.5 mark for other authors				
7.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for second author and 0.25 mark for other authors				
7.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for second author and 0.10 mark for other authors				
7.4	- Each book published (authored) with ISBN No. having minimum 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark - Each edited book having ISBN/proceedings of conference etc. having more than 125 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark				
7.5	Book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in journals not included in (7.1) to (7.3) categories =1st author, 0.5 mark and co-authors, 0.25mark				
7.6	Each short note / communication published in NAAS rated journal = 1 st author, 0.5 and co-authors, 0.25 mark				
7.7	Each abstract published in seminar /symposium /conference/short note papers published in Non- NAAS journals = 1 st author, 0.25 mark and co-authors, 0.10 mark,	02			
7.8	Each popular article published / folder/ leaflet= 0.25 for 1 st author and 0.10 for co- authors	03			
	Note: (a) All the publications should have been published as on the last date prescribed for submission of application. (b) Latest rating declared by NAAS/ UGC listed journals will be considered.				
8.	Additional duties / Institution building: (during the period of Assistant Professor or equivalent)	8.0			
8.1	Additional duties of continuous nature as HoD, Farm Incharge, Chief hostel Warden, Hostel warden, DDO of Units, ADSW, Incharge, NSS/ NCC/ Games & sports/ placement Cell / website/ Establishment / pool/ accounts/ technical cell/ Central Store/ Students section/ Academic/ Asstt. Examination Suptd. / Library/ Central lab/ Land scaping /Nodal officers etc. or other additional duties of continuous nature assigned by the University/Competent authority, to be decided by screening / scrutiny committee. = 2.0 mark for each year				
9.	Total (S.No.1 to 8)	75			
10.	Interview:	25			
	Grand Total (S.No. 9 +10)	100			

Note:

1. *The candidates securing minimum 50% marks of the total score shall be eligible for interview. The candidates must secure 50% marks separately in interview for selection.*
2. *The final selection shall be made based on the total marks obtained in score card and interview.*
3. *Where the number of applications received is large in number and it is not convenient or possible for the University to interview to all those candidates, the University may restrict the number of candidates by screening of applications based on Score card or the university may fix criteria to shortlist the candidates to be called for interview according to number of posts and category.*

Signature of candidate with date

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR DIRECT SELECTION ON THE
POST OF SUBJECT MATTER SPECIALIST

Name:

Subject:.....

S. No	Attributes	Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic background	51			
1.1	Secondary school examination (Percentage of marks x 0.02)	02			
1.2	Hr. Sec.(XI)/Sr. Secondary school (XII or 10+2 level) examination or equivalent (Percentage of marks x 0.03)	03			
1.3	Bachelor's degree (Percentage of marks x 0.17)	17			
1.4	Master's degree (Percentage of marks x 0.21)	21			
1.5	Ph.D. degree (Percentage of marks x 0.08) Candidate having Ph.D. degree without course work will be awarded 4 marks only	08			
Note: (a) If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily attached with the application. However, if the board/ university does not declare equivalent percentage in case of 4 point scale, it shall be determined by the following formula: $Y = (50 - 10X) + 5X^2$, where Y is Equivalent Percentage and X is OGPA obtained in 4 point scale. In case of numerical grading system on 10 point scale the percentage shall be calculated as OGPA multiplied by 10. (b) If the University does not give an overall percentage/ grade point of all years of the degree, then the average of all years/ semesters shall be taken for computation of OGPA or Equivalent percentage.					
2.	Awards & recognitions	07			
2.1	Jawaharlal Nehru award of ICAR for best Ph.D. thesis = 2 marks				
2.2	1.5 marks for Best thesis award at National level and 1.0 marks at University level (If the candidate gets more than one award for the same achievement / thesis; the highest award will be considered for allotting the marks)				
2.3	Chancellor's Gold Medal award = 1.5 marks				
2.4	University gold medal = 1.0 mark each for award at UG and PG level in academics	02			
2.5	JRF/SRF through National Level Exam conducted by UGC/ICAR/CSIR or GATE = 2 marks each	04			
2.6	International/National award / awards from ICAR/ Govt. Institutions = 1.0 mark each	02			
2.7	National level award from Professional Society/Academies = 0.5 mark each	02			
3.	Service Experience	04			
3.1	Each completed year of service experience in Agricultural Research/Extension/Teaching after post-graduation in State and Central Govt./State and Central Universities/ICAR organizations= 1.0 mark				
4.	Participation in seminar/ symposium/ conference/ trainings etc.	03			
4.1	Oral/ poster presentation in National or International seminar/ Symposium/ Conference/ workshop attended in India = 0.5 mark each	01			
4.2	Participation in International seminar/				

		Symposium/ Conference/ workshop, Abroad = 1.0 mark each				
	4.3	Participation in training programme of one week duration or more outside parent University/ Institution in subject area = 1.0 mark each	02			
5.	Publications		10			
	5.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark for second author and 0.5 mark for other authors				
	5.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for second author and 0.25 mark for other authors				
	5.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for second author and 0.10 mark for other authors				
	5.4	- Each book published with ISBN no. having minimum 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark - Each edited book having ISBN/proceedings of conference etc. having more than 125 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark				
	5.5	book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in journals not included in (5.1) to (5.3) categories =1st author, 0.50 mark and co-authors, 0.25mark	03			
	5.6	Each popular article published / folder/ leaflet/ Abstract/ Extended summary= 0.25 for 1 st author and 0.10 for co- authors	02			
	5.7	Each radio talk / T V talk = 0.1 mark	01			
	Note: (a) All the publications should have been published as on the last date prescribed for submission of application. (b) Latest rating declared by NAAS/ UGC listed journals will be considered.					
6.	Co-curricular and Extra- curricular activities		05			
	(a)	Certificate of winner/ runner up at All India Inter University Games & Sports meet/ Youth festivals Participation in State/National level games organized by Govt. recognized bodies/ NCC `C` certificate = 1.0 mark each				
	(b)	Certificate of participation in All India Inter University Games & Sports meet/ Youth festivals/ Republic day parade = 0.5 marks each				
	(c)	NSS certificate/ NCC`B` certificate/ army attachment camp/ participation in Zonal level Inter- University games & sports meet and youth festival = 0.25 marks each				
7.	Total (S.No. 1-6)		80			
8.	Interview		20			
	GRAND TOTAL (S.No. 7+8)		100			

Note:

1. *The candidates securing minimum 50% marks of the total score shall be eligible for interview. The candidates must secure 50% marks separately in interview for selection.*
 2. *The final selection shall be made based on the total marks obtained in score card and interview.*
 3. *Where the number of applications received is large in number and it is not convenient or possible for the University to interview to all those candidates, the University may restrict the number of candidates by screening of applications based on Score card or the university may fix criteria to shortlist the candidates to be called for interview according to number of posts and category.*
 4. *The number of candidates to be called for interview shall be in the ratio of 1:8.*
- If there is tie of score for last candidate, all candidates securing equal marks will be called for interview.*

Signature of candidate with date

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR PERSONAL PROMOTION
UNDER CAS
Assistant Professor stage I to Assistant Professor Stage II (Pay level L-10 to L-11)

Name :

Subject:.....

S. No	Attributes		Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic Background		30			
	1.1	Bachelor's degree (Percentage of marks x 0.08)	08			
	1.2	Master's degree (Percentage of marks x 0.12)	12			
	1.3	Ph.D. degree (Percentage of marks x 0.08) Candidates having Ph.D. degree without course work will be awarded 4.0 marks only.	08			
	1.4	Post-doctoral fellow (0.5 mark for each completed 6 months)	02			
Note: If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily enclosed with the application.						
2.	Experience & Annual Assessment Report:		12			
	2.1	Each year of service experience as Assistant Professor in AGP 6000 = 1.5 mark per year	06			
	2.2	Annual assessment reports of four years, best out of 5/6 years (Outstanding=1.5 mark; Very good= 1.0 mark; Good=0.75 mark and Satisfactory= 0.50 mark per year)	06			
3.	Awards & Recognitions received:		08			
	3.1	Jawahar Lal Nehru award for Ph.D. thesis=02 marks				
	3.2	Best thesis award = 01 marks				
	3.3	Gold medal 1.5 marks each				
	3.4	Awards and recognition during the period of assessment)				
	(a)	Awards at university level / district level =0.5 mark each	02			
	(b)	Individual/team/fellow award by Central Govt. organizations such as ICAR, CSIR, UGC, DBT, DST, National Institutes, FAO/ state government = 1.5 marks each				
	(c)	Fellow/ Award/ recognition by recognized national academies/ Professional societies = 0.5 mark each				
Note: If the award is received by a team, the team leader will get full marks and co-leaders will be awarded half of the allotted marks . If a candidate gets more awards for the same achievement, the highest award will be considered for allotment of marks						
4.	Teaching / Research / Extension attainments (during the period of assessment)*		35			
	4.1	No. of UG/ PG courses taught = 1.0 marks for each course per semester (If courses are taught jointly, the proportionate marks will be considered.)				
	4.2	Ph.D. and Master's thesis guided as major advisor = 2.0 marks and 1.0 mark , each respectively and 0.5 mark and 0.25 mark each respectively as a Member of advisory committee				

*Attach proof duly varied by HOD/PC/OI/ZDR/Dean/ Director

4.3	Each variety developed and released at National Level = Team leader, 3.0 marks and Associates 1.0 mark , Variety developed and released at state level= Team leader, 2.0 marks and Associates 0.75 mark				
4.4	Each patent granted = 3.0 marks				
4.5	Each experiment conducted for the duration of less than 6 months =0.10 marks: for more than 6 months = 0.20 marks.	05			
4.6	Each technology developed and included in the package of practices = 2.0 mark for team leader and 1.0 mark for associates	10			
4.7	Submission and approval of each Project costing Rs. 20.0 lacs or more =Principal Investigator, 2.0 marks and Co-PI/Associate Investigator, 1.0 marks				
4.8	Testing of each project or project allotted by University/Organization costing Rs. 4.0 lacs or more = Principal Investigator, 1.0 mark and Co-PI / Associate Investigator, 0.50 mark	05			
4.9	Each training course of 2 to 6 days duration conducted as organizer for trainers or officers /stake holders/ farmers etc.= 0.50 mark each	05			
4.10	Each training / awareness programme of one day conducted as organiser = 0.25 mark	02			
4.11	Each training course of 7 to 20 days duration conducted as organiser for trainers or officers / stake holders/farmers etc.= 1.0 mark				
4.12	Each training course of more than 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 2.0 marks				
4.13	Each 30 successful FLDs/ other demonstrations and each 10 OFTs conducted as Major contributor = 1.0 mark and Co-contributors = 0.50	03			
4.14	Organization of Kisan Mela at district /division /state/national level = 1.0 mark each for one day and 2.0 marks each for two or more days to main organiser and 50% of marks to other scientists involved	04			
4.15	Each lecture delivered in trainings / field days / kisan mela etc. = 0.25 mark	05			
4.16	Each documentary developed = 1.0 mark	03			
4.17	Each summer / winter school / refresher course etc. for more than 14 days duration conducted as organizer= 1.0 mark and co-organizer = 0.50 mark				
4.18	Each symposium/ seminar/ conference/ workshop / group meeting organized at national level = 1.0 mark and co-organizer = 0.5 mark				
4.19	Each lecture delivered as resource person / Invited lecture in summer / winter school / refresher course/ symposium/ seminar/ conference etc. = 1.0 mark	03			
4.20	Organization of exhibition (exhibits) at other institute = 0.5 mark each	02			
4.21	Each TV/Radio talk = 0.25 mark	02			
4.22	Full time duties of continuous nature other than Teaching / Research / Extension as assigned by the University / Competent authority such as COE/ University DDO/ OSD/ Deputy/ Assistant Registrar, Associate/Deputy/ Assistant Director, O/I of stations or any other to be decided by screening / scrutiny committee = 2.0 marks for each year				

	4.23	Part time duties in preparation of annual reports/ self-study report, Research/ Extension Highlights, Vision document, Editor of University periodicals/ newsletter at University/ Directorate/ College level or any other major documents as assigned by the University = 1.5 mark each as major contributor, 0.75 mark as associate contributor.	03			
5.	Publications: (during the assessment period)		10			
	5.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark co authors				
	5.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for co- authors				
	5.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for co-authors				
	5.4	Book published by National Institute/ Universities/ Standard publishers: - Each authored book having ISBN of more than 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark for book - Each edited book having ISBN/proceedings of conference etc. having more than 100 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark				
	5.5	Book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in journals not included in (5.1) to (5.3) categories =1st author, 0.5 mark and co- authors, 0.25mark				
	5.6	Each short note / communication published in NAAS rated journal = 1 st author, 0.5 and co-authors, 0.25 mark				
	5.7	Each abstract published in proceedings of seminar /symposium /conference or short note papers published in Non- NAAS journals = 1 st author, 0.25 mark and co-authors, 0.10 mark ,	03			
	5.8	Each popular article in reputed magazine / folder/ leaflet= 0.25 for 1 st author and 0.10 for co- authors	05			
6.	Additional duties / Institution building: (during the period of assessment)		5.0			
	6.1	Additional duties of continuous nature as Incharge of Department, farm Incharge, Chief hostel Warden, Hostel warden, DDO of Units, ADSW, Incharge, NSS/ NCC/ Games & Sports/ placement Cell/ website/ Establishment/ pool/ accounts/ technical cell/ Central Store/ Students section/ Academic/ Asstt. Examination Suptd./ Library/ Central lab/ land scaping etc. or other additional duties of continuous nature assigned by the University/Competent authority, to be decided by screening/ scrutiny committee. = 1.0 mark for each year				
Eligibility and criteria CAS promotion from Assistant Professor Stage I to Assistant Professor Stage II shall be conducted by a Screening Cum Evaluation Committee adhering to the criteria laid out as API score in PBAS. Note: 1. Minimum Eligibility : i. Service Requirements: An Assistant Professor with complete services of 4 years possessing Ph.D. degree; 5 years possessing M. Phil/ M. Tech and 6 years without Ph.D. degree in AGP 6000 or Pay level AL 10						

- ii. One orientation and one refresher / research methodology course of 2/3 weeks duration completed during assessment period.
- iii. Published one research publication in the peer-reviewed/ NAAS rated or UGC-listed journals during assessment period
- iv. Minimum API score of 50%

2. CAS promotion Criteria:

- i. Candidate gets a 'satisfactory' or above grade in the annual performance assessment reports of at least three/four/five of the last four/five/six years of the assessment period as the case may be
- ii. The promotion is recommended by the screening-cum evaluation committee.

Signature of candidate

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR PERSONAL
PROMOTION UNDER CAS
Assistant Professor Stage II to Assistant Professor Stage III (Pay Level AL- 11 to AL-12)

Name :

Subject:

S. No	Attributes	Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic Background	25			
1.1	Bachelor's degree (Percentage of marks x 0.07)	07			
1.2	Master's degree (Percentage of marks x 0.08)	08			
1.3	Ph.D. degree (Percentage of marks x 0.07) Candidates having Ph.D. degree without course work will be awarded 4.0 marks only.	07			
1.4	Post-doctoral fellow (0.5 mark for each completed 6 months)	01			
1.5	Special training abroad for more than 3 months= 2marks and if less than 3 months only 1 mark related to subject of specialization	02			
Note: If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily enclosed with the application.					
2.	Experience & Annual Assessment Report:	10			
2.1	Each year of service experience as Assistant Professor in AGP 7000 = 1.0 mark per year	05			
2.2	Annual assessment reports (Outstanding=1.5 mark; Very good= 1.0 mark; Good=0.75 mark and Satisfactory= 0.50 mark per year)	05			
3.	Awards & Recognitions received:	05			
3.1	Jawahar Lal Nehru award for Ph.D. thesis=02 marks				
3.2	Best thesis award = 01 marks				
3.3	Gold medal 1.5 marks each				
3.4	Awards and recognition received during the period of assessment				
(a)	Awards at university level / district level =0.5 mark each	02			
(b)	Individual/team/fellow award by Central Govt. organizations such as ICAR, CSIR, UGC, DBT, DST, National Institutes, FAO/ state government = 1.5 marks each				
(c)	Fellow/ Award/ recognition by recognized national academies/ Professional societies = 0.5 mark each				
Note: If the award is received by a team, the team leader will get full marks and co-leaders will be awarded half of the allotted marks . If a candidate gets more awards for the same achievement, the highest award will be considered for allotment of marks					
4.	Teaching / Research / Extension attainments (during the period of assessment) *	35			
4.1	No. of UG/ PG courses taught = 1.0 marks for each course per semester (If courses are taught jointly, the proportionate marks will be considered.)				

*Attach proof duly varied by HOD/PC/OI/ZDR/Dean/ Director

4.2	Ph.D. and Master's thesis guided as major advisor = 2.0 marks and 1.0 mark , each respectively and 0.5 mark and 0.25 mark each respectively as a member of advisory committee				
4.3	Each variety developed and released at National Level				

	= Team leader, 3.0 marks and Associates 1.0 mark, Variety developed and released at state level= Team leader, 2.0 marks and Associates 0.75 mark				
4.4	Each patent granted = 3.0 marks				
4.5	Each experiment conducted for the duration of less than 6 months =0.10 marks: for more than 6 months = 0.20 marks.	05			
4.6	Each technology developed and included in the package of practices = 2.0 mark for team leader and 1.0 mark for associates	10			
4.7	Submission and approval of each Project costing Rs. 25.0 lacs or more =Principal Investigator, 2.0 marks and Co-PI/Associate Investigator, 1.0 marks				
4.8	Testing of each project or project allotted by University/Organization costing Rs. 4.0 lacs or more = Principal Investigator, 1.0 mark and Co-PI / Associate Investigator, 0.50 mark				
4.9	Each training course of 2 to 6 days duration conducted as organizer for trainers or officers /stake holders/ farmers etc.= 0.50 mark each	05			
4.10	Each training / awareness programme of one day conducted as organiser = 0.25 mark	02			
4.11	Each training course of 7 to 20 days duration conducted as organiser for trainers or officers / stake holders/farmers etc.= 1.0 mark				
4.12	Each training course of more than 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 2.0 marks				
4.13	Each 30 successful FLDs/ other demonstrations and each 10 OFTs conducted as Major contributor = 1.0 mark and Co-contributors = 0.50	03			
4.14	Organization of Kisan Mela at district /division /state/national level = 1.0 mark each for one day and 2.0 marks each for two or more days to main organiser and 50% of marks to other scientists involved	04			
4.15	Each lecture delivered in trainings / field days / kisan mela etc. = 0.25 mark	05			
4.16	Each documentary developed = 1.0 mark	03			
4.17	Each summer / winter school / refresher course etc. for more than 14 days duration conducted as organizer= 1.0 mark and co-organizer = 0.50 mark				
4.18	Each symposium/ seminar/ conference/ workshop / group meeting organized at national level = 1.0 mark and co-organizer = 0.5 mark				
4.19	Each lecture delivered as resource person / Invited lecture in summer / winter school / refresher course/ symposium/ seminar/ conference etc. = 1.0 mark	03			
4.20	Organization of exhibition (exhibits) at other institute = 0.5 mark each	02			
4.21	Each TV/Radio talk = 0.25 mark	02			
4.22	Full time duties of continuous nature other than Teaching / Research / Extension as assigned by the University / Competent authority such as COE/ University DDO/ OSD/ Deputy/ Assistant Registrar, Associate/Deputy/ Assistant Director, O/I of stations or any other to be decided by screening / scrutiny committee = 2.0 marks for each year				
4.23	Part time duties in preparation of annual reports/ self-study report, Research/ Extension Highlights, Vision document, Editor of University periodicals/ newsletter at University/ Directorate/ College level or any other major documents as assigned by the University = 1.5 mark each as major	03			

		contributor, 0.75 mark as associate contributor.				
5.	Publications: (during the assessment period)		15			
5.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark co authors					
5.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for co- authors					
5.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for co-authors					
5.4	Book published by National Institute/ Universities/ Standard publishers: - Each authored book having ISBN of more than 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark for book - Each edited book having ISBN/proceedings of conference etc. having more than 100 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark					
5.5	Book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in journals not included in (5.1) to (5.3) categories =1st author, 0.5 mark and co- authors, 0.25mark					
5.6	Each short note / communication published in NAAS rated journal = 1 st author, 0.5 and co-authors, 0.25 mark					
5.7	Each abstract published in proceedings of seminar /symposium /conference or short note papers published in Non- NAAS journals = 1 st author, 0.25 mark and co-authors, 0.10 mark ,	03				
5.8	Each popular article in reputed magazine / folder/ leaflet= 0.25 for 1 st author and 0.10 for co- authors	05				
6.	Additional duties / Institution building: (during the period of assessment)	10				
6.1	Additional duties of continuous nature as Incharge of Department, farm Incharge, Chief hostel Warden, Hostel warden, DDO of Units, ADSW, Incharge, NSS/ NCC/ Games & Sports / placement Cell / website/ Establishment / pool/ accounts/ technical cell/ Central Store/ Students section/ Academic/ Asstt. Examination Suptd. / Library/ Central lab, land scaping etc. or other additional duties of continuous nature assigned by the University/Competent authority, to be decided by screening / scrutiny committee. = 2.0 mark for each year					
Eligibility and criteria CAS promotion from Assistant Professor Stage II to Assistant Professor Stage III shall be conducted by a Screening Cum Evaluation Committee adhering to the criteria laid out as API score in PBAS. Note: 1. Minimum Eligibility: i. Service requirement: Minimum 5 years of service on the post of Assistant Professor in stage II in AGP 7000/- or Pay level AL 11. ii. A Ph.D. degree in the subject concerned/allied/relevant discipline. iii. One course / programme from among the categories of Methodology, workshops, training, teaching-learning-evaluation technology programme, soft skills development programmes and faculty development programmes of minimum one week						

	duration. iv. Published three research papers in the peer-reviewed /NAAS rated or UGC-listed journals during assessment period. v. Minimum API score of 50%

2. CAS promotion Criteria:

- i. Candidate gets 'satisfactory' or above grade in the annual performance assessment reports of at least four of the last five years of the assessment period

The promotion is recommended by the Screening-cum-evaluation committee.

Signature of candidate

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR PERSONAL PROMOTION UNDER
CAS

Assistant Professor Stage III to Associate Professor stage IV (Pay Level AL-12 to AL-13A)

Name:.....

Subject:.....

S. No	Attributes	Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic Background	20			
1.1	Bachelor's degree (Percentage of marks x 0.04)	04			
1.2	Master's degree (Percentage of marks x 0.06)	06			
1.3	Ph.D. degree (Percentage of marks x 0.07) Candidates having Ph.D. degree without course work will be awarded 4.0 marks only.	07			
1.4	Post-doctoral fellow (0.5 mark for each completed 6 months)	01			
1.5	Special training abroad for more than 3 months= 2marks and if less than 3 months only 1 mark related to subject of specialization	02			
Note: If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily enclosed with the application.					
2.	Experience & Annual Assessment Report:	09			
2.1	Each year of service experience as Assistant Professor in AGP 8000 = 1.5 mark per year	4.5			
2.2	Annual assessment reports (Outstanding=1.5 mark; Very good= 1.0 mark; Good=0.75 mark and Satisfactory= 0.50 mark per year)	4.5			
3.	Awards & Recognitions received:	08			
3.1	Jawahar Lal Nehru award for Ph.D. thesis=02 marks				
3.2	Best thesis award = 01 marks				
3.3	Gold medal 1.5 marks each				
3.4	Awards and recognitions received during the period of assessment				
(a)	Awards at university level / district level =0.5 mark each	02			
(b)	Individual/team/fellow award by Central Govt. organizations such as ICAR, CSIR, UGC, DBT, DST, National Institutes, FAO/ state government = 1.5 marks each				
(c)	Fellow/ Award/ recognition by recognized national academies/ Professional societies = 0.5 mark each				
Note: If the award is received by a team, the team leader will get full marks and co-leaders will be awarded half of the allotted marks . If a candidate gets more awards for the same achievement, the highest award will be considered for allotment of marks					
4.	Teaching / Research / Extension attainments (during the period of assessment)*	25			
4.1	No. of UG/ PG courses taught = 1.0 marks for each course per semester (If courses are taught jointly, the proportionate marks will be considered.)				

*Attach proof duly varied by HOD/PC/OI/ZDR/Dean/ Director

4.2	Ph.D. and Master's thesis guided as major advisor = 2.0 marks and 1.0 mark , each respectively and 0.5 mark and 0.25 mark each respectively as a Member of advisory committee				
4.3	Each variety developed and released at National Level = Team leader, 3.0 marks and Associates 1.0 mark , Variety developed and released at state level = Team leader, 2.0 marks and Associates 0.75 mark				
4.4	Each patent granted = 3.0 marks				
4.5	Each experiment conducted for the duration of less than 6 months =0.10 marks: for more than 6 months = 0.20 marks.	05			
4.6	Each technology developed and included in the package of practices = 2.5 mark for team leader and 1.0 mark for associates				
4.7	Submission and approval of each Project costing Rs. 30.0 lacs or more =Principal Investigator 3.0 marks and Co-PI/Associate Investigator, 2.0 marks				
4.8	Testing of each project or project allotted by University/Organization costing Rs. 4.0 lacs or more = Principal Investigator, 1.0 mark and Co-PI / Associate Investigator, 0.50 mark				
4.9	Each training course of 2 to 6 days duration conducted as organizer for trainers or officers /stake holders/ farmers etc.= 0.50 mark each	03			
4.10	Each training / awareness programme of one day conducted as organiser = 0.25 mark	02			
4.11	Each training course of 7 to 20 days duration conducted as organiser for trainers or officers / stake holders/farmers etc.= 1.0 mark				
4.12	Each training course of more than 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 2.0 marks				
4.13	Each 30 successful FLDs/ other demonstrations and each 10 OFTs conducted as Major contributor = 1.0 mark and Co-contributors = 0.50	03			
4.14	Organization of <i>Kisan Mela</i> at district /division /state/national level = 1.0 mark each for one day and 2.0 marks each for two or more days to main organiser and 50% of marks to other scientists involved	04			
4.15	Each lecture delivered in trainings / field days / kisan mela etc. = 0.25 mark	03			
4.16	Each documentary developed = 1.0 mark	03			
4.17	Each summer / winter school / refresher course etc. for more than 14 days duration conducted as organizer= 1.0 mark and co-organizer = 0.50 mark				
4.18	Each symposium/ seminar/ conference/ workshop / group meeting organized as organizer = 1.0 mark and co-organizer = 0.5 mark				
4.19	Each lecture delivered as resource person / Invited lecture in summer / winter school / refresher course/ symposium/ seminar/ conference etc. = 1.0 mark	02			
4.20	Organization of exhibition (exhibits) at other institute = 0.5 mark each	02			
4.21	Each TV/Radio talk = 0.25 mark	02			
4.22	Full time duties of continuous nature other than Teaching / Research / Extension as assigned by the University / Competent authority such as COE/ University DDO/ OSD/ Deputy/ Assistant Registrar, Associate/Deputy/ Assistant Director, O/I of stations or any other to be decided by screening / scrutiny committee = 3.0 marks for each year				

		Part time duties in preparation of annual reports/ self-study report, Research/ Extension Highlights, Vision document, Editor of University periodicals/ newsletter at University/ Directorate/ College level or any other major documents as assigned by the University = 1.5 mark each as major contributor, 0.75 mark as associate contributor.	03			
5.	Publications: (during the assessment period)		10			
	5.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark co authors				
	5.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for co- authors				
	5.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for co-authors				
	5.4	Book published by National Institute/ Universities/ Standard publishers: - Each authored book having ISBN of more than 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark for book - Each edited book having ISBN/proceedings of conference etc. having more than 100 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark				
	5.5	Book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in journals not included in (5.1) to (5.3) categories =1st author, 0.5 mark and co- authors, 0.25mark				
	5.6	Each short note / communication published in NAAS rated journal = 1 st author, 0.5 and co-authors, 0.25 mark				
	5.7	Each abstract published in proceedings of seminar /symposium /conference or short note papers published in Non- NAAS journals = 1 st author, 0.25 mark and co-authors, 0.10 mark ,	03			
	5.8	Each popular article in reputed magazine / folder/ leaflet= 0.25 for 1 st author and 0.10 for co- authors	05			
6.	Additional duties / Institution building: (during the period of assessment)		8.0			
	6.1	Additional duties of continuous nature as Incharge of Department, farm Incharge, Chief hostel Warden, Hostel warden, DDO of Units, ADSW, Incharge, NSS/ NCC/ Games & Sports / placement Cell / website/ Establishment / pool/ accounts/ technical cell/ Central Store/ Students section/ Academic/ Asstt. Examination Suptd. / Library/ Central lab, land scaping etc. or other additional duties of continuous nature assigned by the University/Competent authority, to be decided by screening / scrutiny committee. = 2.0 mark for each year				
7.	Interview:		20			
The score would be considered during assessment period only. The CAS promotion from Assistant Professor Stage III to Associate Professor Stage IV shall be conducted through personal interview by selection committee.						

Eligibility and criteria

1. Minimum Eligibility:

- i. Service requirement: Minimum 3 years of service on the post of Assistant Professor in stage III in AGP 8000/- or Pay Level AL 12.
- ii. A Ph.D. degree in the subject concerned/allied/relevant discipline.
- iii. A minimum of 07 publications in the peer-reviewed journals out of which 03 research papers should have been published during the assessment period.
- iv. One course / programme from among the categories of Methodology, workshops, training, teaching-learning-evaluation technology programme, soft skills development programmes and faculty development programmes of minimum one week duration.
- v. Minimum API score of 50%

CAS promotion Criteria:

- i. Candidate gets 'satisfactory' or above grade in the annual performance assessment reports of at least two of the last three years of the assessment period
- ii. A selection committee as stipulated in regulation of direct recruitment shall be applicable for the interview for the post of Associate Professor under CAS.

The candidate must secure 50 % marks separately in interview for promotion.

Signature of candidate

AGRICULTURE UNIVERSITY, KOTA
SCORE CARD OF ACADEMIC PERFORMANCE INDICATOR (API) FOR PERSONAL
PROMOTION UNDER CAS
Associate Professor or equivalent post Stage IV to Professor Stage V (Pay Level AL-13 A to AL-14)

Name :

Subject:

S. No	Attributes	Maximum Score	Candidate's score	Page no. of proof	Scrutiny committee's score
1.	Academic Background	15			
1.1	Bachelor's degree (Percentage of marks x 0.02)	02			
1.2	Master's degree (Percentage of marks x 0.04)	04			
1.3	Ph.D. degree (Percentage of marks x 0.05) Candidates having Ph.D. degree without course work will be awarded 4.0 marks only.	05			
1.4	Post-doctoral fellow (0.5 mark for each completed 6 months)	02			
1.5	Special training abroad for more than 3 months= 2marks and if less than 3 months only 1 mark related to subject of specialization	02			
Note: If the University/Board gives grading instead of percentage, the equivalent percentage shall be as declared /certified by the concerned University/Board and the certificate/declaration shall be compulsorily enclosed with the application.					
2.	Experience & Annual Assessment Report:	09			
2.1	Each year of service experience as Associate Professor in AGP 9000 = 1.5 mark per year	4.5			
2.2	Annual assessment reports (Outstanding=1.5 mark; Very good= 1.0 mark; Good=0.75 mark and Satisfactory= 0.50 mark per year)	4.5			
3.	Awards & Recognitions:	10			
3.1	Jawahar Lal Nehru award for Ph.D. thesis= 02 marks				
3.2	Best thesis award = 01 marks				
3.3	Gold medal 1.5 marks each				
3.4	Award and recognition received during the period of assessment				
(a)	Awards at university level / district level =0.5 mark each	02			
(b)	Individual/team/fellow award by Central Govt. organizations such as ICAR, CSIR, UGC, DBT, DST, National Institutes, FAO/ state government = 1.5 marks each				
(c)	Fellow/ Award/ recognition by recognized national academies/ Professional societies = 0.5 mark each				
Note: If the award is received by a team, the team leader will get full marks and co-leaders will be awarded half of the allotted marks . If a candidate gets more awards for the same achievement, the highest award will be considered for allotment of marks					
4.	Teaching / Research / Extension attainments (during the period of assessment)*	24			
4.1	No. of UG/ PG courses taught = 1.0 marks for each course per semester (If courses are taught jointly, the proportionate marks will be considered.)				

*Attach proof duly varied by HOD/PC/OI/ZDR/Dean/ Director

4.2	Ph.D. and Master's thesis guided as major advisor = 2.0 marks and 1.0 mark , each respectively and 0.5 mark and 0.25 mark each respectively as a member of advisory committee				
4.3	Each variety developed and released at National Level = Team leader, 3.0 marks and Associates 1.0 mark , Variety developed and released at state level= Team leader, 2.0 marks and Associates 0.75 mark				
4.4	Each patent granted = 3.0 marks				
4.5	Each experiment conducted for the duration of less than 6 months =0.10 marks: for more than 6 months = 0.20 marks.	05			
4.6	Each technology developed and included in the package of practices = 2.0 mark for team leader and 1.0 mark for associates	10			
4.7	Submission and approval of each Project costing Rs. 50.0 lacs or more =Principal Investigator 4.0 marks and Co-PI/Associate Investigator, 2.0 marks				
4.8	Testing of each project or project allotted by University/Organization costing Rs. 4.0 lacs or more = Principal Investigator, 1.0 mark and Co-PI / Associate Investigator, 0.50 mark				
4.9	Each training course of 2 to 6 days duration conducted as organizer for trainers or officers /stake holders/ farmers etc.= 0.50 mark each	03			
4.10	Each training / awareness programme of one day conducted as organiser = 0.25 mark	02			
4.11	Each training course of 7 to 20 days duration conducted as organiser for trainers or officers / stake holders/farmers etc.= 1.0 mark				
4.12	Each training course of more than 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 2.0 marks				
4.13	Each 30 successful FLDs/ other demonstrations and each 10 OFTs conducted as Major contributor = 1.0 mark and Co-contributors = 0.50	03			
4.14	Organization of <i>Kisan Mela</i> at district /division /state/national level = 1.0 mark each for one day and 2.0 marks each for two or more days to main organiser and 50% of marks to other scientists involved	04			
4.15	Each lecture delivered in trainings / field days / kisan mela etc. = 0.25 mark	03			
4.16	Each documentary developed = 1.0 mark	03			
4.17	Each summer / winter school / refresher course etc. for more than 14 days duration conducted as organizer= 1.0 mark and co-organizer = 0.50 mark				
4.18	Each symposium/ seminar/ conference/ workshop / group meeting organized at national level = 1.0 mark and co-organizer = 0.5 mark				
4.19	Each lecture delivered as resource person / Invited lecture in summer / winter school / refresher course/ symposium/ seminar/ conference etc. = 1.0 mark	02			
4.20	Organization of exhibition (exhibits) at other institute = 0.5 mark each	02			
4.21	Each TV/Radio talk = 0.25 mark	02			
4.22	Full time duties of continuous nature other than Teaching / Research / Extension as assigned by the University / Competent authority such as COE/ University DDO/ OSD/ Deputy/ Assistant Registrar, Associate/Deputy/ Assistant Director, O/I of stations or any other to be decided by screening / scrutiny committee = 3.0 marks for each year				
4.23	Part time duties in preparation of annual reports/	03			

		self-study report, Research/ Extension Highlights, Vision document, Editor of University periodicals/ newsletter at University/ Directorate/ College level or any other major documents as assigned by the University = 1.5 mark each as major contributor, 0.75 mark as associate contributor.				
5.	Publications: (during the assessment period)		14			
	5.1	Paper published in journals having NAAS rating 6.0 and above or journals listed in UGC- Care list Group II = 2.0 marks each for 1 st author and 1.0 mark co authors				
	5.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for co- authors				
	5.3	Paper published in journals having NAAS rating below 4.00 or journals listed in UGC- Care list Group I = 1.0 marks each for 1 st author and 0.5 mark for co-authors				
	5.4	Book published by National Institute/ Universities/ Standard publishers: - Each authored book having ISBN of more than 100 pages = 1st author, 2.0 marks and co-authors = 1.0 mark for book - Each edited book having ISBN/proceedings of conference etc. having more than 100 pages =1st Editor, =1.0 mark and Co-editors, =0.5 mark				
	5.5	Book chapter in books having ISBN/ laboratory or practical manual / extension bulletin/ technical bulletin/ full length paper published in proceedings of National/ International seminar/ symposium/ conference/ research paper published in journals not included in (5.1) to (5.3) categories =1st author, 0.5 mark and co- authors, 0.25mark				
	5.6	Each short note / communication published in NAAS rated journal = 1 st author, 0.5 and co-authors, 0.25 mark				
	5.7	Each abstract published in proceedings of seminar /symposium /conference or short note papers published in Non- NAAS journals = 1 st author, 0.25 mark and co-authors, 0.10 mark ,	03			
	5.8	Each popular article in reputed magazine/ folder/ leaflet= 0.25 for 1 st author and 0.10 for co- authors	05			
6.	Additional duties / Institution building: (during the period of assessment)		8.0			
	6.1	Additional duties of continuous nature as HoD, farm Incharge, Chief hostel Warden, Hostel warden, DDO of Units, ADSW, Incharge, NSS/ NCC/ Games & Sports/ placement Cell/ website/ Establishment/ pool/ accounts/ technical cell/ Central Store/ Students section/ Academic/ Asstt. Examination Suptd./ Library/ Central lab, land scaping etc. or other additional duties of continuous nature assigned by the University/Competent authority, to be decided by screening/ scrutiny committee. = 2.0 mark for each year				
7.	Interview:		20			
The score would be considered during assessment period only. The CAS promotion from Associate Professor to Professor shall be conducted through personal interview by selection committee.						
Eligibility and criteria						
1. Minimum Eligibility:						
i. Service requirement: Minimum 3 years of service on the post of Associate Professor or equivalent in stage IV i.e. in AGP 9000/- or Pay level AL 13A						

- ii. A Ph.D. degree in the subject concerned/allied/relevant discipline.
 - iii. A minimum of ten research publications in the peer- reviewed journals out of which three research papers should have been published during the assessment period.
 - iv. Minimum API score of 50%
- 2. CAS promotion Criteria**
- i. Candidate gets 'satisfactory' or above grade in the annual performance assessment reports of at least two of the last three years of the assessment period
 - ii. A selection committee as stipulated in regulation of direct recruitment shall be applicable for the interview for the post of Professor under CAS.
- The candidate must secure 50 % marks separately in interview for promotion.

Signature of candidate

AGRICULTURE UNIVERSITY, KOTA

Reservation Roster of Teaching Cadre Posts

(As per Reservation Rules of Government of Rajasthan: BC-21%, SC- 16%, ST-12%, MBC-5%, EWS-10%)

S.N.	Name of cadre	Cadre Strength	No. of posts to be advertised	UR	BC	SC	ST	MBC	EWS
1.	Professor	11	06	04	01	01	-	-	-
2.	Associate Professor	35	11	04	02	02	01	01	01
3.	Senior Scientist & Head	06	04	02	01	01	-	-	-
4.	Assistant Professor/ Assistant Librarian	144	46	16	10	07	05	03	05

Reservation Roster for the cadre of Subject Matter Specialist

(As per Reservation Rules of Government of Rajasthan: BC-21%, SC- 16%, ST-12%, MBC-5%, EWS-10%)

S.N.	Name of cadre	Cadre Strength	No. of posts to be advertised	UR	BC	SC	ST	MBC	EWS
1.	Subject Matter Specialist	19	04	02	01	-	01	-	-


REGISTRAR

Reservation Roster the Non- teaching Cadre posts
(As per Reservation Rules of Government of Rajasthan: BC-21%, SC- 16%, ST-12%, MBC-5%, EWS-10%)

S.N.	Name of cadre	Cadre Strength	No. of posts to be advertised	UR	BC	SC	ST	MBC	EWS
1.	Assistant Registrar	02	01	01	-	-	-	-	-
2.	Technical Assistant/ Farm Manager	40	04	-	01	01	-	01	01
3.	Lab Technician	02	02	02	-	-	-	-	-
4.	Agriculture Supervisor	23	02	-	-	01	-	-	01
5.	Lab Assistant	19	05	01	01	01	01	-	01
6.	Library Assistant	03	01	01	-	-	-	-	-
7.	Shelf Assistant/ Book Lifter	01	01	01	-	-	-	-	-
8.	Personal Assistant	04	01	01	-	-	-	-	-
9.	Stenographer (State plan/ non-plan)	08	01	01	-	-	-	-	-
10.	Stenographer (KVK plan)	06	03	03	-	-	-	-	-
11.	LDC (Clerk Gr. II)/ Store Keeper	25	06	05	01	-	-	-	-
12.	Matron/ Hostel care taker	04	10	03	02	02	01	-	02
13.	Driver T-1 (KVK plan)	12	02	02	-	-	-	-	-
14.	Driver (State Plan)	14	08	06	01	01	-	-	-
15.	Lab Attendant/ Class IV	78	01	-	-	01	-	-	-
			11	-	02	03	03	01	02


REGISTRAR



N K Jain, RAS
REGISTRAR

**OFFICE OF REGISTRAR
AGRICULTURE UNIVERSITY, KOTA**
BORKHERA, BARAN ROAD, KOTA 324001 (RAJ.)

कृषि विश्वविद्यालय, कोटा
बोरखेडा, बारा रोड, कोटा 324001 (राज.)



Tel : 0744-2321205
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No. F. ()/AUK/ aca.council/2021/ 8263-76

Date: 23/09/2021

NOTIFICATION

In pursuance to resolution No. AUK/AC-17/2021-01/03 of the 17th Academic Council meeting held on 20.07.2021 and subsequent approval in BOM-17/2021/03, the newly created teaching post for the College of Agriculture, Hindoli (Bundi) vide Government of Rajasthan letter No. प.1(03)कृषि -3/2021 दिनांक 07.04.2021 the distribution of posts in different disciplines of the colleges is hereby notified as under:-

I. College of Agriculture, Hindoli:

S.No.	New Post Created	Number	Department/ Discipline
A.	Associate Professor	02	1. Agronomy (01) 2. Genetics & Plant Breeding (01)
B.	Assistant Professor	10	1. Soil Science(01) 2. Entomology(01) 3. Plant Pathology(01) 4. Horticulture (01) 5. Agronomy (01) 6. Extension Education (01) 7. Agricultural Engineering (01) 8. Agricultural Economics (01) 9. Statistics(01) 10. Computer science (01)

REGISTRAR

Copy to the following for information:

1. PS to Hon'ble Vice-Chancellor, Agriculture University, Kota.
2. Director Extension Education/Research/HRD/PM&E/DSW/Education. Agriculture University Kota.
3. Dean College of Horticulture & Forestry Jhalawar/College of Agriculture Unmedganj Kota/Hindoli.
4. Comptroller. Agriculture University, Kota
5. OSD, Recruitment. Agriculture University, Kota
6. Controller of Examinations, Agriculture University Kota
7. PF/GF

REGISTRAR

Agriculture University, Kota
Best Teacher/Extension Educationist/Research Scientist Award

General guidelines

1. **Name of award:** Agriculture University's "Best Teacher/ Extension Educationist / Research Scientist" award for the excellence in the field of teaching, extension & research respectively. The award will carry a cash prize of Rs. 10,000/- along with a certificate and a memento.
2. **Presentation of award:** The award will be presented to the selected candidate on **26th January** of every year at the Republic day ceremony of the University or Foundation Day Ceremony of the University.
3. **Objective:** To recognize the talented faculty who has shown excellence in the field of Agriculture Education, Research and Extension.
4. **Number and frequency :** The number of awards will be **ONE** in each field (Education, Research and Extension) every year as per suitability .
5. **Eligibility:** The entire faculty including Professor, Associate Professor/Senior Scientist & Head and Assistant Professor/SMS posted in Teaching/Research / Extension for a minimum of last five years. The applicant must have at least 5 years of service experience in the university including probation period. The applicant is expected to be a role model with high moral values and must not have been penalized or any enquiry pending against him/her. For which the controlling officers will submit a certificate along with application form. Persons holding the post of Deans/Directors/COE etc. are not eligible for the award.
6. **Administration of the award:**
 - i. The applications / proposals will be invited by the Director, HRD in the month of October of every year and unit/Officer In-charge will forward only best three based on score to the reviewing officer for onward submission.
 - ii. To evaluate the applications and make recommendation, there shall be a screening committee comprising of Director HRD as convener and members (one Dean/ Director) along with at least one external expert (Professor/ Dean/ Director (working or retired) from outside of the AU, Kota) will be nominated/invited by the Hon'ble Vice Chancellor, AU, Kota.
 - iii. The screening committee will prepare a merit list based on score obtained in score card (90 marks) and three candidates in order of merit will be called for presentation (10 marks) before the screening committee under the chairmanship of Hon'ble Vice Chancellor, AU, Kota. The final score will be calculated by adding marks obtained in score card and presentation/ interaction.
 - iv. In case of tie (equal score) between two candidates, the candidate having more age/ experience will be given preference.
 - v. Once awarded, the employee will not be eligible for consideration of the award for next 5 years.
 - vi. Award will be given only if the candidate is getting more than 60 % marks in score card.
 - vii. Award may be given to a suitable candidate even if single application is received and fulfill the criteria for the award.
 - viii. All the publications should have been published as on the last date prescribed for submission of application.
7. **Evaluation criteria :** As per attached score card (Annexure-I/II/III)
8. **Procedure:**

- i. The applicant will fill up application on prescribed format and submit it to respective Unit In-charge and Dean or Director for onward transmission to University.
- ii. The Dean/Director after having nomination from each College/KVK/Department/Research Centre will forward applications after verifying the information and mentioning the full justification that "How he/she is eligible for this recognition".
- iii. **The applications should be invited every year by the Director, HRD in the month of October, so as to reach on or before December 31st of every year.**
- iv. The applications, complete in all respect should reach to the office of the Director, HRD on or before December 31st of every year. Applications received after due date will not be considered in any case.
- v. The decision of the committee will be final and not be reviewable or can not be challenged, RTI, and for legal case (if any) Kota will be the jurisdiction area only.
- vi. **Guidelines for Filling the Assessment Reports.**

Post / Cadre of Candidate	Reporting Officer	Reviewing Officer
Professor / Associate Professor/ Assistant Professor / SMS	Concern ZDR / Officer / Unit Incharge /HOD/Senior Scientist & Head	Concern Dean / Director
Officer / Unit Incharge/ZDR/ /Senior Scientist & Head / HOD	Concern Dean / Director	Concern Dean / Director
If a candidate is working in the University H.Q.	Concern Controlling Officer	Concern Controlling Officer

Agriculture University, Kota
Application / Score Card for
Best Teacher Award – (Year : -----)

A. Personal information.

1.	Name of the Candidate	:						Paste your recent passport size photo
2.	Father's name	:						
3.	Date of birth	:						
4.	Designation	:						
5.	Date of joining university services	:						
6.	Details of Working in the Project/Unit	:	Post	Name of Project / Unit	From	To	No. of years	
7.	Date of holding present post	:						
8.	Email ID	:						
9.	Mobile Number	:						

B. Academic Performance Indicators (Max 100 marks)
(minimum 5 years of continuous service required)

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Reporting Officer Score	Reviewing Officer Score	Screening committee's score
1.	Contribution in major field of teaching (during last 5 years)	45					
1.1	No. of UG/ PG/Ph.D. courses taught = 0.5 mark / course / semester						
1.2	Ph.D. and Master's thesis guided as major advisor = 2.0 marks and 1.0 mark , each respectively and 0.5 mark and 0.25 mark each respectively as a Member of advisory committee	5.0					
1.3	Placement of students obtained PG degree under your guidance (0.50 mark for each placement)	5.0					
1.4	No. of theses selected for award/recognition etc., if any during reporting period (1.0 mark for each award)	5.0					
1.5	Preparation of laboratory/practical manuals, etc. during reporting period (0.50 mark for each manual)	5.0					
1.6	Membership of professional societies during reporting period (0.50 mark for each life membership)	2.0					
1.7	Organization of Winter/ Summer school course (21 days) = 4.0 marks for Coordinator, and 2.0 marks for each Course Co-ordinator(s)	4.0					

1.8	Organization of short duration course (7 or 14 days) = 2.0 marks for Coordinator, and 1.0 mark for each Course Co-ordinator(s)	2.0					
1.9	Exposure visit/ Educational tour (not less than 4 days) of students at National level = 2 marks , State level = 1 mark for each tour	5.0					
1.10	Lectures delivered in winter/summer school (0.5 mark for each lecture)	5.0					
1.11	Gross income generated (Seed/Planting material/tasting/RAWE/produce from units 0.5 mark per lakh	5.0					
1.12	Organization of seminar/ symposium/ workshop as Coordinator= 2.0 marks , each organizer/secretary= 1.0 mark , members = 0.5 mark	5.0					
Total Out of 45							
2.	Contribution in allied field of research/extension (during last 5 years)	10					
2.1	Research Projects (Externally funded / Adhoc / RKVY/ etc.) received, 0.2 mark per lac outlay for P.I. and 0.1 marks for CoP.I.	10.0					
2.2	Contribution in AICRP (per year) 1.0 mark for PI and 0.50 mark for Co-PI	5.0					
2.3	Each technology developed and included in the package of practices at national level = 2.5 marks for team leader and 1.25 mark for associates . State / Zonal Recommendations (2 marks for each for main contributor & 1.0 mark for real associates)	5.0					
2.4	Testing of each project or project allotted by University/Organization costing Rs.2.0 lacs or more = 1.0 mark for PI and 0.50 mark for Co-PI	5.0					
2.5	Each patent granted/ variety developed and released at National Level = 3.0 marks for Team leader and 1.5 marks for Associate , Variety developed and released at state level= 2.0 marks for Team leader and 1.0 mark for Associate	5.0					

2.6	Each training upto 6 days duration conducted as organizer for farmers = 0.50 mark	5.0					
2.7	Each skill development training course of 7 to 20 days duration conducted as Coordinator for farmers etc.= 1.0 mark	5.0					
2.8	Each skill development training course of more than 20 days duration conducted as Coordinator for farmers etc.= 2.0 marks	5.0					
2.9	Each lecture delivered in trainings/ TV/ Radio Talk etc. = 0.25 mark	5.0					
2.10	Each success story published/ documented = 0.5 mark	5.0					
Total out of 10							
3.0	Additional duties of continuous nature (during last 5 years) as Head of Unit, DDO of Unit, Hostel Warden/ ADSW/ Incharge of Student section/ Establishment/ Accounts/ Library/ NCC/ NSS/ Sports/ Instructional Farm/ EL unit/ RAWE/HWE/FOWE / Revolving Fund/ Guest House / Technical cell/ Centre Store/ Nodal Officer of scheme/ Editor of magazine etc. or other additional duties of continuous nature assigned by the Competent authority, to be decided by screening committee. = 0.5 mark for each year	5.0					
Total Out of 5							
4.	Publications (during stipulated period of 5 years)	10					
4.1	Paper published in journals having NAAS rating 6.0 and above = 2.0 marks each for 1 st author and 1.0 mark for co authors						
4.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for co- authors						
4.3	Paper published in journals having NAAS rating below 4.00 = 1.0 marks each for 1 st author and 0.5 mark for co-authors	5.0					
4.4	Book published by standard publisher having ISBN (more than 100 pages)= 2.0 marks	4.0					
4.5	Technical Bulletin / Research bulletin / Edited	4.0					

	Book/Manuals/practical manuals/ lab manuals /Proceedings of seminar/ conference etc. (more than 25 pages) etc = 1.0 mark each for 1 st author and 0.5 mark for co-authors						
4.6	Full length paper/extended summary/short notes in proceedings of seminar/ symposia/ conference, paper published in non- NAAS rated journals/Book Chapter = 0.5 mark each for 1 st author and 0.25 mark for co-authors	2.0					
4.7	Abstract published in seminar/ symposia/ conference proceedings/ popular article/ folder /leaflet etc. = 0.25 mark each for 1 st author and 0.10 mark for co-authors	2.0					
4.8	University documents / Reports (Research Highlights, Souvenir/Univ./ Unit Annual progress reports / at a glance/University progress report/decade of research or any other university documents, etc.) = 0.5 mark each for 1 st main contributor and 0.25 mark for cooperators decided by the Dean.	2.5					
	Total out of 10						
5.	Trainings attended	5.0					
5.1	International / National Trainings attended in Abroad / India (in the area relevant field only) for more than 20 days = 2.0 marks ; less than 20 days = 01 mark	2.5					
5.2	International / National seminar / symposium / conference attended = 0.25 mark and act as convener/ chairman / rapporteur etc. = 0.5 mark	2.5					
	Total out of 5						
6.	Awards/ Recognitions during last five years	5					
6.1	Individual/ team award by Central Govt. / ICAR, CSIR, UGC, DBT, DST, National Institutes/ state government/ district administration / University = 2 marks each						
6.2	Award/ recognition/ medal						

	received from professional societies/ Best paper/ poster/ exhibition award received/Appreciation certificate by Univ. = 1 mark each						
	Total out of 5						
Note: (a) All the publications should have been published as on the last date prescribed for submission of application. (b) Latest rating declared by NAAS will be considered.							
7	Assessment by reporting officer/ reviewing officer	10					
7.1	Assessment of the candidate by ZDR / Officer Incharge/ Unit Incharge (As per Attached Assessment Sheet)	5.0					
7.2	Assessment of the candidate by Dean.	5.0					
	Total out of 10						
	Grand Total (1-7) out of 90						
8	Presentation by the candidates (three candidates in order of merit of score card of 90 marks) to be decided by the screening committee.	10					
	Total out of 10						
	Grand Total out of 100						

C. Write (not exceeding 500 words) a note in support of your candidature for the said award:

Declarations by the employee

I, ...S/o or D/o working as at..... hereby certify that the information given here in are true and correct to the best of my knowledge. In the event of any information found to be incorrect my candidature be disqualified for the award and shall be liable for disciplinary action against me. I have not been felicitated by this award in past 5 years of my service in the university

Signature of Candidate

Assessment of the candidate (Max 10 marks)

Recommendations of Reporting Officer

(Confidential)

D. Reporting officer shall put his/ her initial in the appropriate column against each factor

S. No.	Factor	Outstanding (0.5 mark)	Very good (0.25 mark)	Good (0.1 mark)	Total
1.	Punctuality				
2.	Aptitude				
3.	Output of work				
4.	Quality of output				
5.	Professional competence				
6.	Decision making ability				
7.	Leadership quality				
8.	Innovativeness				
9.	Team spirit				
10.	Promptness in assigned work				
11.	Student feedback				

- i. This is certified that the incumbent was not penalized and no memo issued/ disciplinary action pending during the last five years.
- ii. This is certified that I have checked and verified the information furnished by the candidate is true and correct.

(Signature of Reporting Officer)

E. Remarks of Reviewing Officer highlighting 1 or 2 most significant contribution of the candidate made during last five years and how best he/she justified for this recognition.

- (i)
- (ii)
- (iii)

(Signature of Reviewing Officer)

Guidelines for Filling the Assessment Reports

Post/Cadre of Candidate	Reporting Officer	Reviewing Officer
Professor / Associate Professor/ Assistant Professor/ SMS	HOD/ZDR/ Unit Incharge/ Senior Scientist & Head/PI	Dean/ Director
Senior Scientist & Head/ Head of Department/ Unit Incharge	Dean/ Director	Dean/ Director
If a candidate is working in the University H.Q.	Concern Controlling Officer	Concern Controlling Officer

Agriculture University, Kota
Application / Score Card for
Best Research Scientist Award – (Year: -----)

A. Personal information.

1.	Name of the Candidate	:						Paste your recent passport size photo
2.	Father's name	:						
3.	Date of birth	:						
4.	Designation	:						
5.	Date of joining university services	:						
6.	Details of Working in the Project/Unit	:	Post	Name of Project / Unit	From	To	No. of years	
7.	Date of holding present post	:						
8.	Email ID	:						
9.	Mobile Number	:						

B. Academic Performance Indicators (Max 100 marks)**(minimum 5 years of continuous service required)**

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Reporting Officer Score	Reviewing Officer Score	Screening committee's score
1.	Contribution in Major field of Research (during last 5 years)	45					
1.1	Varieties Developed as developer (Developed, Notified & Released) CVRC variety – 3.0 marks for each for developer and 1.5 marks for real associates						
1.2	SVRC - 2 marks for each for developer and 1.0 for real associates subject to included in POP						
1.3	Recommendations included in Package of Practices (POP) - Crop Improvement / Production / Protection / Horticulture etc.						
1.3.1	National Recommendations (2.5 marks for each for main contributor & 1.25 mark for real associates)						
1.3.2	State / Zonal Recommendations (2 marks for each for main contributor & 1.0 mark for real associates)						
1.4	Patents obtained / Prototype developed (5 marks for each for main contributor & 2.5 for associates)	5.0					
1.5	Developed Technologies / varieties commercialized (Breeder seed indent	5.0					

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Reporting Officer Score	Reviewing Officer Score	Screening committee's score
	received (0.1 mark for 1000 q) / Sold to entrepreneurs (2 marks for each for main contributor & 1.0 mark for associates)						
1.6	Research Projects (Externally funded /Adhoc / DBT/DST/RKVY/etc.) (subject to minimum outlay of Rs. 25 lac) received 0.2 mark per lac total outlay for P.I. and 0.1 marks for CoP.I.	20.0					
1.7	Sponsored adhoc /Projects (Private) (only will be considered if final report submitted within 3 months after experimentation)	10.0					
1.7.1	Sponsored adhoc / Projects (Private) brought by the Scientist & Conducted)- Bioefficacy /Residual/ testing of variety/other products etc. – 0.5 mark per lac outlay for P.I. & 0.25 mark for CoPI	5.0					
1.7.2	Sponsored adhoc/ Projects (Private) allotted by DOR and only conducted by the scientist); Bioefficacy / Residual / testing of variety/other product / etc. - 0.25 mark per lac outlay for P.I. & 0.1 mark for CoPI	5.0					
1.8	Gross Income generated (Seed /Produce/Products sell /Live units/testing / labs/Consultancy etc.) (income below 0.1 lac will not be considered) = 0.5 mark per lac gross income. (Certificate will be issued by the Unit I/C based on the record).	30.0					
1.9	Infrastructure developed/created (Labs/ Live units/Buildings etc.) cost below 1.0 lac will not be considered = 0.25 mark for per lac (Certificate will be issued by the Unit I/C based on the record).	5.0					
	Total out of 45						
2.	Contribution in allied field of teaching/extension (during last 5 years)	10					
2.1	No. of UG/ PG courses taught = 0.5 marks / course / semester						
2.2	Ph.D. and Master's thesis guided as major advisor = 2.0 marks and 1.0 mark , each respectively and 0.5 mark and 0.25 mark each respectively as a Member of advisory committee , DE nominee including .	5.0					
2.3	Organization of International seminar / symposium / workshop / Conference as Organizing Coordinator / Chairman /	5.0					

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Reporting Officer Score	Reviewing Officer Score	Screening committee's score
	Member Secretary = 2.5 mark each & for Committees convener / members 1.25 mark each						
2.4	Organization of National / State / District seminar symposium / workshop / Conference as Organizing Coordinator / Chairman / Member Secretary = 1.0 mark each & Committees convener/members 0.5 mark each	5.0					
2.5	Organization of National / State / District e-Webinars /seminar symposium / workshop / Conference as Organizing Coordinator / Chairman / Member Secretary = 0.5 mark each & Committees convener/members 0.25 mark each	5.0					
2.5	Organization of e-Webinars of 1-2 days /National / State / District seminar symposium / workshop / Conference as Organizing Coordinator / Chairman / Member Secretary = 0.25 mark each & Committees convener/members 0.1 mark each	5.0					
2.6	Organization of e-Webinars of more than 3-7 days /National / State / District seminar symposium / workshop / Conference as Organizing Coordinator / Chairman / Member Secretary = 0.5 mark each & Committees convener/members 0.25 mark each	5.0					
2.7	Organization of University events – Research council / Foundation day / Convocation /PRT/QRT/ZREAC/ Kisan mela / exhibition/others as Organizing Coordinator / Chairman / Member Secretary = 1.0 mark each & Committees convener/members 0.5 mark each	5.0					
2.8	Each training upto 6 days duration conducted for trainers as Organizing Coordinator/organizer / Member Secretary = 1.0 mark each & 0.5 mark for associates	5.0					
2.9	Each training upto 6 days duration conducted as conducted as Coordinator/organizer for farmers = 5.0 mark each & 0.25 mark for associates	5.0					
2.10	Each training of 7 to 20 days duration conducted for trainers as Organizing Coordinator/organizer / Member Secretary = 2.0 mark each & 1.0 mark	5.0					

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Reporting Officer Score	Reviewing Officer Score	Screening committee's score
	for associates						
2.11	Each training of 7 to 20 days duration conducted as Organizing Coordinator/organizer/Member Secretary for farmers etc.= 1.0 mark & 0.5 mark for associates	5.0					
2.12	Each training course of more than 20 days duration conducted as as Organizing Coordinator/organizer/Member Secretary etc.= 2.0 marks	5.0					
2.13	Each lecture delivered in trainings/Farmers fair/ TV/ Radio Talk/Field days etc. = 0.25 mark	5.0					
2.14	Each success story published / documented = 0.5 marks	5.0					
2.15	FLDs conducted (mini 5 successful FLD) and other demonstrations = 1.0 mark for major contributor and 0.50 mark for Co-contributors	5.0					
2.16	Organization of Field days/MGMG/Smart village etc. as coordinator /Convenor = 0.5 marks and Associates 0.25 marks	5.0					
2.17	Development of Mobile app / kisan call centre/ Custom hiring centre/ Film / Video Clipping of technologies prepared etc. = 1.0 mark for major contributor and 0.50 mark for Co-contributors	2.0					
2.18	Impact studies / Case studies with report submission (0.5 each)	2.0					
	Total out of 10						
3.0	Additional duties of continuous nature (during last 5 years)- (Must be minimum of continuous period of one year) assigned by the Competent authority or to be decided by the screening committee. Head of Unit / Officer Incharge /Add.Dir / Dy.Dir./ Asstt.Dir./ Nodal Officer/ Farm Incharge /Technical Cell I/C / Off campus Incharge / D.D.O / Add. Unit Incharge / Pool Incharge/ Establishment Incharge / Finance Incharge /Library Incharge /Legal Cell Incharge /G.H. Incharge /Campus beautification Incharge /Master trainer / Editor of magazine etc./ Incharge Central store / Building / P.I. of the AICRP or Voluntary center / PHC/ CoNodal officer/editor of magazine/ Convener / Member of various	5.0					

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Reporting Officer Score	Reviewing Officer Score	Screening committee's score
	committee at research unit of continuous nature etc. – 0.5 marks for each year						
	Total Out of 5						
4.	Publications (during stipulated period of 5 years)	10					
4.1	Paper published in journals having NAAS rating 6.0 and above = 2.0 marks each for 1 st author and 1.0 mark for co authors						
4.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for co- authors						
4.3	Paper published in journals having NAAS rating below 4.00 = 1.0 mark each for 1 st author and 0.5 mark for co-authors	5.0					
4.4	Book published by standard publisher having ISBN (more than 100 pages)= 2.0 marks	4.0					
4.5	Technical Bulletin / Research bulletin / Edited Book/Manuals/practical manuals/lab manuals /Proceedings of seminar/conference etc. (more than 25 pages) etc = 1.0 mark each for 1 st author and 0.5 mark for co-authors	4.0					
4.6	Full length paper/extended summary/short notes in proceedings of seminar/ symposia/ conference, paper published in non- NAAS rated journals/Book Chapter = 0.5 mark each for 1 st author and 0.25 mark for co-authors	2.0					
4.7	Abstract published in seminar/ symposia/ conference proceedings/ popular article/ folder /leaflet etc. = 0.25 mark each for 1 st author and 0.10 mark for co-authors	2.0					
4.8	University documents / Reports (Research Highlights, Souvenir/Univ./ Unit Annual progress reports / at a glance/University progress report/decade of research or any other university documents, etc.) = 0.5 mark each for 1 st main contributor and 0.25 mark for cooperators decided by the Director Research.	2.5					
	Total out of 10						
5.	Trainings attended	5.0					

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Reporting Officer Score	Reviewing Officer Score	Screening committee's score
5.1	International / National Trainings attended in Abroad / India (in the area relevant field only) for more than 20 days = 2.0 marks ; less than 20 days = 01 mark	2.5					
5.2	International / National seminar / symposium / conference attended = 0.25 mark and act as convener/ chairman / rapporteur etc. = 0.5 mark	2.5					
	Total out of 5						
6.	Awards/ Recognitions during last five years	5					
6.1	Individual/ team award by Central Govt. / ICAR, CSIR, UGC, DBT, DST, National Institutes/ state government/ district administration / University = 2 marks each						
6.2	Award/ recognition/ medal received from professional societies/ Best paper/ poster/ exhibition award received/Appreciation certificate by Univ. = 1 mark each						
	Total out of 5						
Note:							
(c) All the publications should have been published as on the last date prescribed for submission of application.							
(d) Latest rating declared by NAAS will be considered.							
7	Assessment by reporting officer/ reviewing officer	10					
7.1	Assessment of the candidate by ZDR / Officer Incharge/Unit Incharge (As per Attached Assessment Sheet)	5.0					
7.2	Assessment of the candidate by Director Research	5.0					
	Total out of 10						
	Grand Total (1-7) out of 90						
8	Presentation by the candidates (three candidates in order of merit of score card of 90 marks) to be decided by the screening committee.	10					
	Total out of 10						
	Grand Total out of 100						

C. Write a specific note (not exceeding one page) in support of your candidature for the said award :

Declarations by the Candidate

I,.....S/o/D/o, working as at..... Since, hereby certify that the information given here in are true and correct to the best of my knowledge. The information's given are as per the guidelines and In the case of any information found to be incorrect/false, my candidature be disqualified for the award and shall be liable for disciplinary action against me. I have not been felicitated by this award in past 5 years of my service in the Agriculture University, Kota.

Date :

Signature of Candidate

Assessment of the candidate (Max 10 marks)

Recommendations of Reporting Officer

(Confidential)

D. Reporting officer shall put his/ her initial in the appropriate column against each factor

(Only Good to Outstanding will be considered and AAR should also be kept in mind)

S. No.	Factor	Outstanding (0.5 mark)	Very Good (0.25 mark)	Good (0.1 mark)	Total
1.	Punctuality				
2.	Aptitude				
3.	Output of work				
4.	Quality of output				
5.	Professional competence				
6.	Decision making ability				
7.	Leadership quality				
8.	Innovativeness				
9.	Team spirit				
10.	Promptness to complete assigned work				
	Total out of 5.0				

- This is certified that the incumbent was not penalized and no memo issued/ disciplinary action pending during the last five years.
- This is certified that I have checked, verified and satisfied by the information furnished by the candidate are true and correct.

Date:

(Seal & Signature of Reporting Officer)

E. Remarks of Reviewing Officer highlighting 2-3 most significant contribution of the candidate made during last five years and how best he/she justified for this recognition.

(i)

(ii)

(iii)

Date:

(Seal & Signature of Reviewing Officer)

Guidelines for Filling the Assessment Reports

Post/Cadre of Candidate	Reporting Officer	Reviewing Officer
Professor / Associate Professor/ Assistant Professor/ SMS	HOD/ZDR/ Unit Incharge/ Senior Scientist & Head/PI	Dean/ Director
Senior Scientist & Head/ Head of Department/ Unit Incharge	Dean/ Director	Dean/ Director
If a candidate is working in the University H.Q.	Concern Controlling Officer	Concern Controlling Officer

Agriculture University, Kota
Application / Score Card for
Best Extension Educationist Award – (Year : -----)

A. Personal information.

1.	Name of the Candidate	:						Paste your recent passport size photo
2.	Father's name	:						
3.	Date of birth	:						
4.	Designation	:						
5.	Date of joining university services	:						
6.	Details of Working in the Project/Unit	:	Post	Name of Project / Unit	From	To	No. of years	
7.	Date of holding present post	:						
8.	Email ID	:						
9.	Mobile Number	:						

B. Academic Performance Indicators (Max 100 marks)**(minimum 5 years of continuous service required)**

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Screening committee's score
1.	Contribution in major field of Agriculture Extension (during last 5 years)	45			
1.1	Each 20 successful FLDs and other demonstrations conducted = 1.0 mark for Major contributor and 0.50 mark for Co-contributor	5.0			
1.2	Each 10 successful OFTs conducted = 1.0 mark for Major contributor and 0.50 mark for Co-contributor	5.0			
1.3	Each success story published/ documented = 0.5 marks	4.0			
1.4	Each training / awareness programme/ field day/ of one day duration conducted as organiser = 0.25 mark	4.0			
1.5	Each training course of 2 to 6 days duration conducted as organizer for trainers or officers /stake holders/ farmers etc.= 0.50 mark each	4.0			
1.6	Each skill development training course of 7 to 20 days duration conducted as organiser for trainers or officers / stake holders/farmers etc.= 1.0 mark	5.0			
1.7	Each skill development training course of more than 20 days duration conducted as organizer for trainers or officers / stake holders/farmers etc.= 2.0 marks	10.0			
1.8	Organization of <i>Kisan Mela</i> at district /division /state/national level = 1.0 mark each for one day and 2.0 marks each for two or more days to main organiser and 50% of marks to other scientists involved	4.0			

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Screening committee's score
1.9	Each lecture delivered in trainings / field days / kisan mela etc. = 0.25 mark	4.0			
1.10	Development of Mobile app / You tube channel/ community radio station/ <i>kisan</i> call centre/ Custom hiring centre etc. = 2.0 marks each	4.0			
1.11	Interstate exposure visit conducted = 1.0 mark each	4.0			
1.12	Development of new live demonstration Unit = 2.0 marks each	4.0			
1.13	Organization of animal health camp/ workshop/ seminar/ symposium/ farmer's scientist interaction etc. = 1.0 mark each	4.0			
1.14	Formation of SHGs/ FIGs = 1.0 mark each	4.0			
1.15	Formation of FPO = 2.0 marks each	4.0			
1.16	Representing University in Kisan mela/ other program/ (outside university) and installing exhibition = 1 mark each	4.0			
1.17	TV/ Radio Talk = 0.25 marks each	4.0			
1.18	Facilitator for National/ state level award for farmer = 1.0 mark each	2.0			
1.19	Gross income generated (Seed/Planting material/testing/RAWE/produce from units in a financial year 0.5 marks per lakh	5.0			
Total out of 45					
2.	Contribution in allied field of teaching and research (during last 5 years)	10			
2.1	No. of UG/ PG courses taught = 0.5 marks / course / semester				
2.2	Ph.D. and Master's thesis guided as major advisor = 2.0 marks and 1.0 mark , each respectively and 0.5 mark and 0.25 mark each respectively as a Member of advisory committee	5.0			
2.3	Each patent granted / variety developed and released at National Level = 3.0 marks for Team leader, and 1.5 marks for Associate , Variety developed and released at state level= 2.0 marks for Team leader, and 1.0 mark for Associate				
2.4	Approval of Projects (Externally funded / Adhoc / RKVY/ etc.) 0.2 mark per lac outlay	10.0			
2.5	Each technology developed and included in the package of practices at national level = 2.5 marks for team leader and 1.25 mark for associates . State / Zonal Recommendations (2 marks for each for main contributor & 1.0 mark for real associates)	5.0			
2.6	Testing of each project or project allotted by University/Organization costing Rs.2.0 lacs or more = 1.0 mark for PI and 0.50 mark for Co-PI	5.0			

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Screening committee's score
	Total out of 10				
3.0	Additional duties of continuous nature (during last 5 years) as Head of Unit, DDO of Units, Incharge of website/ Establishment / accounts/ technical cell/ Store/ Library/ Soil testing lab/ Processing unit/ farm / Nursery/ Orchard/ RAWE / Guest House / Asstt. Director/ Nodal Officer of schemes/ editor of magazine etc. or other additional duties of continuous nature assigned by the Competent authority, to be decided by screening committee. = 0.5 mark for each year	5.0			
	Total Out of 5				
4.	Publications (during stipulated period of 5 years)	10			
4.1	Paper published in journals having NAAS rating 6.0 and above = 2.0 marks each for 1 st author and 1.0 mark for co authors				
4.2	Paper published in journals having NAAS rating from 4.00 to 5.99 = 1.5 marks each for 1 st author and 0.75 mark for co- authors				
4.3	Paper published in journals having NAAS rating below 4.00 = 1.0 marks each for 1 st author and 0.5 mark for co-authors	5.0			
4.4	Book published by standard publisher having ISBN (more than 100 pages)= 2.0 marks	4.0			
4.5	Technical Bulletin / Extension bulletin / Edited Book/Manuals/practical manuals/lab manuals /Proceedings of seminar/conference etc. (more than 25 pages) etc = 1.0 marks each for 1 st author and 0.5 mark for co-authors	4.0			
4.6	Full length paper/extended summary/short notes in proceedings of seminar/ symposia/ conference, paper published in non- NAAS rated journals/Book Chapter = 0.5 mark each for 1 st author and 0.25 mark for co-authors	2.0			
4.7	Abstract published in seminar/ symposia/ conference proceedings/ popular article/ folder /leaflet etc. = 0.25 marks each for 1 st author and 0.10 mark for co-authors	2.0			
	Total out of 10				
5.	Trainings attended	5.0			
5.1	International / National Trainings attended in Abroad / India (in the area relevant field only) for more than 20 days = 2.0 marks ; less than 20 days = 01 mark	2.5			
5.2	International / National seminar / symposium / conference attended = 0.25 mark and act as convener/ chairman /	2.5			

S. No	Attributes	Max. Score	Candidate Self Assess Score	Page No. of proof	Screening committee's score
	rapporteur etc. = 0.5 mark				
	Total out of 5				
6.	Awards/ Recognitions during last five years	5			
6.1	Individual/ team award by Central Govt. / ICAR, CSIR, UGC, DBT, DST, National Institutes/ state government/ district administration / University = 2 marks each				
6.2	Award/ recognition/ medal received from professional societies/ Best paper/ poster/ exhibition award received/Appreciation certificate by Univ. = 1 mark each				
	Total out of 5				
Note: (e) All the publications should have been published as on the last date prescribed for submission of application. (f) Latest rating declared by NAAS will be considered.					
7	Assessment by reporting officer/ reviewing officer	10			
7.1	Assessment of the candidate by Unit In-charge/ Director Extension Education (As per Attached Assessment Sheet)	10			
	Grand Total (1-7) out of 90				
8	Presentation by the candidates (three candidates in order of merit of score card of 90 marks) to be decided by the screening committee.	10	--	--	
	Grand Total out of 100		--	--	

C. Write (not exceeding 500 words) a note in support of your candidature for the said award:

Declarations by the employee

I, ...S/o or D/o working as at..... hereby certify that the information given here in are true and correct to the best of my knowledge. In the event of any information found to be incorrect my candidature be disqualified for the award and shall be liable for disciplinary action against me. I have not been felicitated by this award in past 5 years of my service in the university

Signature of Candidate

Assessment of the candidate (Max 10 marks)

Recommendations of Reporting Officer

(Confidential)

D. Reporting officer shall put his/ her initial in the appropriate column against each factor

S. No.	Factor	Outstanding (0.5 mark)	Very good (0.25 mark)	Good (0.1 mark)	Total
1.	Punctuality				
2.	Aptitude				
3.	Output of work				
4.	Quality of output				
5.	Professional competence				
6.	Decision making ability				
7.	Leadership quality				
8.	Innovativeness				
9.	Team spirit				
10.	Promptness in assigned work				

- i. This is certified that the incumbent was not penalized and no memo issued/ disciplinary action pending during the last five years.
- ii. This is certified that I have checked and verified the information furnished by the candidate is true and correct.

(Signature of Reporting Officer)

E. Remarks of Reviewing Officer highlighting 1 or 2 most significant contribution of the candidate made during last five years and how best he/she justified for this recognition.

(i)

(ii)

(iii)

(Signature of Reviewing Officer)

Guidelines for Filling the Assessment Reports

Post/Cadre of Candidate	Reporting Officer	Reviewing Officer
Professor / Associate Professor/ Assistant Professor/ SMS	HOD/ZDR/ Unit Incharge/ Senior Scientist & Head/PI	Dean/ Director
Senior Scientist & Head/ Head of Department/ Unit Incharge	Dean/ Director	Dean/ Director
If a candidate is working in the University H.Q.	Concern Controlling Officer	Concern Controlling Officer

Revised proceeding as per the suggestions and recommendations made by 19th Academic Council for proposing qualification, eligibility, scheme of examination and selection criteria of various non teaching posts through direct recruitment, Agriculture University, Kota

In reference to the University Office order vide F.()/AU/Kota/Recdt./2022/20563-70 Dated 08.02.2022, a committee was constituted to finalizing the qualification, eligibility, scheme of examination and selection criteria of various non-teaching post through direct recruitment. In continuation of the meeting which was held on Dated 24.03.2022 and 25.03.2022, further, in reference to the Registrar letter no. 23040-41 Dated: 28.03.2022, the review meeting of the committee was held on dated 05.04.2022 and the matter was discussed and reviewed.

In continuation to the above meetings and to incorporate the suggestions and recommendations made by 19th Academic Council for proposing qualification, eligibility, scheme of examination and selection criteria of various non teaching posts through direct recruitment, a meeting was held on dated 12.04.2022. The suggestions and recommendations were incorporated and submitted for further needfulness.

The Following committee member were present in the meeting.

All the points regarding the qualification, eligibility, scheme of examination and selection criteria of various non-teaching posts was churn out and discussed very thoroughly by the committee, hence, the supported and keen documents related to recruitments of the various universities and other recruiting institutions were taken into consideration.

1. Dr. Pratap Singh, Director Research, AU, Kota – Convener
2. Dr. Mukesh Chand Goyal, Director PM&E, AU, Kota- Member
3. Dr. Virendra Singh, Controller of Examinations, AU, Kota- Member
4. Dr. C.B. Meena, Assoc. Professor COA, Kota- Member Secretary

Committee has recommended the following points for further refinement/updates.

- One member must be included in the above committee from the University Administration i.e. Registrar or Comptroller or both looking to the non-teaching cadres/posts because some of keen & concrete policy decisions have to be taken and incorporated as per the need for finalizing the criteria for direct recruitment of non-teaching post looking to the legal aspects.

CB Meena

V Singh

hsh *hsh*

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The committee proposed the below mention Qualification for direct recruitment of the following Non-teaching post mentioned below:

S. no.	Name of Post	Qualification	Suggested/Remarks	Scheme of examination	Selection criteria
1.	Assistant Registrar	Graduate from a recognized university having 5 years experience as Sr. PA (Senior Personal Assistant or Section Officer) or graduate from a recognized university having 5 year office management (establishment/accounts/students) experience in pay scale of Rs. 9300-34800/- grade pay Rs. 4800/- (pre-revised) working in central Govt./State Govt./ICAR/PSU/Govt. Funded Universities/Boards/Local Authorities /Institutions may also apply for the post. As per Notification number HRD/Notification/2018/7741-61 dated 20.09.2018 (Annexure-I)	Master or an equivalent Degree in any discipline from any Govt. recognized university with at least 55 Per cent marks having 3 years office or teaching experience. At least three years' administrative experience in supervisory or equivalent cadre in a Group "B" post in a Government Department/ University/ Educational or Research Institution/ Teaching and/ or Research Experience on a substantive post along with proven administrative capabilities. OR 3 Years experience as Section Officer in a Central/State University. Annexure -VIII	If the candidates are applied in large numbers then a screening test will be conducted, if needed.	On the basis of Interview. Further, if the candidates are applied in large number (more than 25) then university can decide to conduct the screening test for Interview.
2.	Technical Assistant/Farm Manager	B.Sc. (Hons) Agriculture /B.Sc. (Hons) Horticulture	B.Sc. Agriculture / B.Sc. (Hons) Agriculture / B.Sc. Horticulture /B.Sc. (Hons) Horticulture/ B.Sc. Forestry/ B.Sc. (Hons) Forestry	Enclose page no 1 to 3	80 percent marks obtained in the written examination + 20 % marks weightage of interview and merit will prepared on the basis of total marks obtained
3.	LDC	(a) Senior Secondary from a recognized board or its equivalent examination and (b) "O" or Higher level certification course conducted by DOEACC under control of the department of electronics, Govt. of India Or Certificate course on computer concept by NILET, New Delhi Or Computer Operator and programming assistant (COPA)/ Data preparation and computer software (DPCS) certificate organized under		As per Annexure -III (LDC Grade-II)	Merit Basis: Based on the marks obtained in the written examination conducted on the basis of prescribed syllabus.

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S. no.	Name of Post	Qualification		Scheme of examination	Selection criteria
		Existing (AU, Kota)	Suggested/Remarks		
		national/state council of vocational training scheme Or Degree/Diploma certificate in Computer Science/ computer science engineering / Computer application from a university/ polytechnic institution recognized by the Govt. Or Senior Secondary certificate from recognized board of secondary education in the country, with the computer science/ computer application as one of the subjects Or Rajasthan state certificate course in information technology (RSCIT) conduct by the Vardhman Mahaveer Open University, Kota under control of Rajasthan knowledge corporation limited.			
4.	Stenographer (Hindi/English)	Senior Secondary from a recognized board or its equivalent examination and (b) "O" or Higher level certification course conducted by DOEACC under control of the department of electronics, Govt. of India Or Certificate course on computer concept by NILET, New Delhi Or Computer Operator and programming assistant (COPA)/ Data preparation and computer software (DPCS) certificate organized under national/state council of vocational training scheme Or Degree/Diploma certificate in computer science/ Computer application from a university established by law in India or from an institution recognized by the Govt. Or Senior Secondary certificate from recognized	a) Senior Secondary from a recognized board or its equivalent examination AND (b) "O" or Higher level certification course conducted by DOEACC under control of the department of electronics, Govt. of India OR Certificate course on computer concept by NILET, New Delhi OR Computer Operator and programming assistant (COPA)/ Data preparation and computer software (DPCS) certificate organized under national/state council of vocational training scheme OR Degree/Diploma certificate in	As per Annexure –IV	Merit Basis: Based on the marks obtained in the written examination conducted on the basis of prescribed syllabus followed by requisite Professional Efficiency Test (Type Test). For Professional Efficiency Test (Type Test), the candidate will be called upon in the 1:8 ratio.

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S. no.	Name of Post	Qualification		Scheme of examination	Selection criteria
		Existing (AU, Kota)	Suggested/Remarks		
		board of secondary education in the country, with the computer science/ computer application as one of the subjects Or Diploma in computer science and engineering from a polytechnic institution recognized by the Govt. Or Rajasthan state certificate course in information technology (RSCIT) conduct by the Vardhman Mahaveer Open University, Kota under control of Rajasthan knowledge corporation limited.	Computer Science/ computer science engineering / Computer application from a university/ polytechnic institution recognized by the Govt. OR Senior Secondary certificate from recognized Board of Secondary Education in the country, with the computer science/ computer application as one of the subjects OR Rajasthan State Certificate Course in Information Technology (RSCIT) conduct by the Vardhman Mahaveer Open University, Kota under control of Rajasthan knowledge corporation limited. (As per Rajasthan Staff Selection Board advertisement Dated: 04.07.2018. Professional Efficiency should be included :- The candidate has to appear in dictation test in English/Hindi (Shorthand) with speed 80 W.P.M. for 10 minutes. The candidate will be required to transcribe this matter in 50 minutes on computer. (As per SKRAU Recruitment Advertisement. No. 02/2022 dated 23.03.2022) (Annexure-II)		
5.	Driver	VIII class passed with heavy and light duty driving license and three years experience as driver must also possess the following :- • Weight not more than 65 kg.	(a) Senior Secondary from board of secondary education, Rajasthan or any other board recognized by the Govt.	Reference page 28	As per Notification number AU/Kota/2018/11797-806 dated 21.12.18 (Annexure-V) point no.3

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S. no.	Name of Post	Qualification		Scheme of examination	Selection criteria
		Existing (AU, Kota)	Suggested/Remarks		
		- Sight 6x6 with or without glasses. - Knowledge of road side vehicle repairs and efficiency in driving to be examined through at trade test by the appointing authority.	(b) Must hold a valid license for driving heavy motor vehicle and transport vehicle (c) Must also possess the following : 1. Sight 6X6 with or without glasses. 2. Knowledge of road side vehicle repairs and efficiency in driving 3. Three years experience of driving after obtaining valid driving license for driving motor vehicle and transport vehicle. 4. The age of the candidate must have attained the age of 18 years must not have attained the age of 40 years on the first day of January next following the last day fixed for receipt of application. Age and age relaxation as per the Rules of Govt. of Rajasthan. (Notification : No.F.3(2)DOP/A-11/2017 dated 26.04.2017) 5. Ideal body weight 6. Efficiency in driving to be examined through at trade test by the appointing authority.		
6.	Shelf Assistant/Book Lifter	Candidate must Passed Secondary with Minimum 55 Per cent Marks from any recognized Board of Secondary Education And Must have 2 years experience in any recognized College/University library.	Candidate must Passed Secondary with minimum 55 per cent Marks from any recognized Board of Secondary Education. And Must have 2 years experience in any recognized College/University/Govt. recognized Library.	Candidate must have Passed Secondary with Minimum 55 Per cent Marks from any recognized Board of Secondary Education	Merit the Basis: Based on the marks obtained in the written examination conducted on the basis of prescribed syllabus.

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S. no.	Name of Post	Qualification		Scheme of examination	Selection criteria
		Existing (AU, Kota)	Suggested/Remarks		
7.	Lab Technician	---	Graduate in Agriculture / Horticulture / Forestry	Reference page no 1 to 3 of T.A.	Merit Basis: Based on the marks obtained in the written examination conducted on the basis of prescribed syllabus.
8.	Store keeper	(a) Senior Secondary from a recognized board or its equivalent examination and (b) "O" or Higher level certification course conducted by DOEACC under control of the department of electronics, Govt. of India Or Certificate course on computer concept by NILET, New Delhi Or Computer Operator and programming assistant (COPA)/ Data preparation and computer software (DPCS) certificate organized under national/state council of vocational training scheme Or Degree/Diploma certificate in computer science/ computer science engineering /Computer application from a university established by law in India or from an institution recognized by the Govt. Or Senior Secondary certificate from recognized board of secondary education in the country, with the computer science/ computer application as one of the subjects Or Diploma in computer science and engineering from a polytechnic institution recognized by the Govt. Or Rajasthan state certificate course in information technology (RSCIT) conducted by the Vardhman Mahaveer Open University, Kota under control of Rajasthan knowledge corporation limited.	---	As per LDC Grade-II, Page No. 01 to 06 Annexure -III	Merit Basis: Based on the marks obtained in the written examination conducted on the basis of prescribed syllabus

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S. no.	Name of Post	Qualification		Scheme of examination	Selection criteria
		Existing (AU, Kota)	Suggested/Remarks		
9.	Hostel Care Taker	--	Essential qualification :- Graduate from any recognized university	Reference page 19 to 21	Merit Basis: Based on the marks obtained in the written examination.
10.	Library Assistant	Essential qualification :- Higher Secondary (11 th) / Senior Secondary (12 th or 10 + 2) and equivalent examination passed with diploma from recognized university in library science. Desirable qualification :- Graduate degree in library science/information science from any recognized university or graduation in equivalents.	Essential qualification :- Higher Secondary (11 th) / Senior Secondary (12 th or 10 + 2) and equivalent examination passed with diploma from recognized university in library science. Desirable qualification :- Diploma/Graduate degree in Library Science/Information Science from any recognized University /Govt. approved Institution	Reference page 25 to 27	Merit Basis: Based on the marks obtained in the written examination
11.	Lab Assistant	Senior higher secondary passed with science including agriculture science from any recognized board.	Higher Secondary / Senior Secondary (10+2) or its equivalent examination passed with science including agriculture science from any recognized board. (As per SKRAU Recruitment Advertisement. No. 02/2022 dated 23.03.2022) (Annexure-II)	As per enclosed Page No 7 to 14	Merit Basis: Based on the marks obtained in the written examination
12.	Agriculture Supervisor	Senior secondary in agriculture from Board of Secondary Education Rajasthan or any other Board recognized by the Government	B.Sc. (Hons) Agriculture / B.Sc. (Hons) Horticulture from recognized university of India Or Passed under 10 + 2 or Higher Secondary with Agriculture from Board of Secondary Education Rajasthan or any other Board recognized by the Government (RSMSSB, Govt. Rajasthan) (Annexure-VI)	As per enclosed Page No 4-6	Merit Basis: Based on the marks obtained in the written examination
13.	Lab Attendant	Secondary from Board of Secondary Education Rajasthan or any other Board recognized by the Government.	---	As per Annexure -VII	Merit Basis: Based on the marks obtained in the written examination.

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Virendra Singh

Mukesh Chand Goyal

Pratap Singh

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S. no.	Name of Post	Qualification		Scheme of examination	Selection criteria
		Existing (AU, Kota)	Suggested/Remarks		
14.	Class IV	Essential :- 8 th pass Desirable :- Secondary pass	Secondary from Board of Secondary Education Rajasthan or any other Board recognized by the Government. (Notification : No.F.3(2)DOP/A-II/2017 dated 26.04.2017) (Annexure-VIII)	As per guidelines of DOP, GoR	Merit Basis: Based on the marks obtained in the written examination.

Recommendation and suggestions made by the 19th Academic Council Meeting:-

1. The house approved the **Table Agenda-I** with certain modifications and suggestions. The house and external members recommended and also suggested by the committee, there should be administrative officers in the already constituted committee i.e. Registrar will act as a Convener and Comptroller as a member, as it is pre-requisite for finalization of the norms and legal aspects for the recruitment of Non-teaching posts.
2. The Scheme of examinations, selection criteria and the syllabus for all the above post will be decided and prepared by a separate committee.
3. Reservation, Age/Age relaxation will be as per the rules of Govt. of Rajasthan.

C B Meena
Dr. C.B. Meena
Associate Professor
College of Agriculture, Kota
(Member Secretary)

Virendra Singh
Dr. Virendra Singh
Controller of Examinations,
AU, Kota
(Member)

Mukesh Chand Goyal
Dr. Mukesh Chand Goyal
Director PM&E,
AU, Kota
(Member)

Pratap Singh
Dr. Pratap Singh
Director Research,
AU, Kota
(Convener)

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राजस्थान कर्मचारी चयन बोर्ड, जयपुर

राज्य कृषि प्रबंध संस्थान परिसर, दुर्गापुरा, जयपुर-302018 दूरभाष नं. 0141-2722520

क्रमांक: प.14(68)RSSB/अर्थना/शीघ्र.लि./भर्ती/2018/ 2957

दिनांक : 04.07. 2018

विज्ञापन सं. 13/2018

शीघ्रलिपिक (Stenographer) संयुक्त सीधी भर्ती परीक्षा-2018

राजस्थान सचिवालय मंत्रालयिक सेवा नियम-1970, राजस्थान लोक सेवा आयोग(लिपिकवर्गीय एवं अधीनस्थ) नियम तथा विनियम, 1999 एवं राजस्थान अधीनस्थ एवं मंत्रालयिक सेवा नियम-1999 के अन्तर्गत कमशः शासन सचिवालय, राजस्थान लोक सेवा आयोग एवं प्रशासनिक सुधार विभाग के माध्यम से राज्य सरकार के अधीनस्थ विभागों/कार्यालयों के लिये शीघ्रलिपिक के रिक्त पदों पर भर्ती हेतु ऑनलाइन आवेदन पत्र (On Line Application Form) आमंत्रित किये जाते हैं :-

क्र.सं.	विभाग का नाम	पद का नाम	गैर अनुसूचित क्षेत्र	अनुसूचित क्षेत्र	कुल योग
1.	शासन सचिवालय	शीघ्रलिपिक	70	—	70
2.	राजस्थान लोक सेवा आयोग	शीघ्रलिपिक	05	—	05
3.	राज्य के अधीनस्थ विभाग/कार्यालय	शीघ्रलिपिक	958	52	1010
कुल पद			1033	52	1085

विशेष नोट :-

(1) On line Application Form में समस्त वांछित सूचना अवश्य अंकित करे। ऑनलाईन आवेदन भरने से पूर्व बोर्ड की वेबसाईट पर उपलब्ध इस विज्ञापित को ध्यानपूर्वक पढ़ लें तथा इसमें दिये गए निर्देशों को ध्यान में रखते हुए आवेदन भरें। कोई सूचना गलत या अपूर्ण भरने पर आवेदक का आवेदन पत्र रद्द कर उसे परीक्षा में प्रवेश नहीं दिया जायेगा, जिसकी जिम्मेदारी स्वयं आवेदक की होगी तथा गलत सूचना या अपूर्ण आवेदन के सुधार हेतु पत्र व्यवहार स्वीकार नहीं किया जाएगा।

(2) आरक्षण की स्थिति एवं नियुक्ति प्रक्रिया राज्य सरकार के निर्देशों एवं नवीनतम नियमों के अधीन परिवर्तनीय होगी।

1. **आवेदन प्रक्रिया:-** आवेदन On line Application Form में लिये जाएंगे जिन्हे राज्य के निर्धारित ई-मित्रकियोस्क/जन सुविधा केन्द्रके माध्यम से भरा जा सकता है। अभ्यर्थी ऑनलाईन आवेदन करने से पूर्व अपना e-mail ID बना ले एवं e-mail ID एवं Password याद रखें। यदि आवेदक ई-मित्र कियोस्क/ जन सुविधा केन्द्र के माध्यम से आवेदन भरता है तो ई-मित्र/जन सुविधा केन्द्र संचालक सबसे पहले बोर्ड की वेबसाईट www.rsmssb.rajasthan.gov.in पर जाकर recruitment पर Click करेगा। संबंधित भर्ती परीक्षा के सामने Apply Online पर Click करने पर Login Page खुलेगा जिसमें ई-मित्र/जन सुविधा केन्द्र संचालक अभ्यर्थी के SSO ID एवं passwordसे Login कर अभ्यर्थी का आवेदन भरेगा। जो अभ्यर्थी पहले से पंजीकृत नहीं है उसका पहले Not a Registered User Link पर Click कर www.sso.rajasthan.gov.in पर उसका पंजीयन करेंगे। पंजीयन के उपरांत उसका SSO ID एवं password प्राप्त कर Login करेंगे। ई-मित्र/जन सुविधा केन्द्र संचालक आवेदक का आवेदन पत्र पूर्ण रूप से भरने के बाद Application preview Page खोलकर अभ्यर्थी को उसका भरा हुआ आवेदन दिखायेगा। अभ्यर्थी स्वयं अपने भरे हुए आवेदन की पुनः गहनता से जांच करेगा। यदि आवेदन में कोई त्रुटि रह जाती है तो ई-मित्र कियोस्क संचालक अभ्यर्थी के आवेदन में आवेदक से परामर्श कर त्रुटियों को दूर करेगा। त्रुटियों को सुधारने के बाद आवेदक को पुनः उसके आवेदन का Preview दिखाकर यह सुनिश्चित करेगा कि आवेदन पत्र में भरी गई समस्त प्रविष्टियां पूर्ण रूप से सही है। सही-सही आवेदन भरने के बाद Submit पर Click करेगा। इसके बाद आवेदन में कोई संशोधन नहीं किया जा सकेगा। सम्पूर्ण आवेदन भरने के बाद अपनी श्रेणी के अनुसार निर्धारित परीक्षा शुल्क ई-मित्र कियोस्क पर जमा करावें। इस हेतु अभ्यर्थी द्वारा रुपये 30/- (रुपये 20/- आवेदन पत्र भरने हेतु + रुपये 10/- परीक्षा शुल्क जमा कराने हेतु) सेवा प्रदाता को सेवा शुल्क के रूप में देना होगा। आवेदन भरने के बाद अभ्यर्थी ई-मित्र कियोस्क संचालक से भरे हुए आवेदन की हार्ड कॉपी मूल रसीद आवश्यक रूप से प्राप्त करें। आवेदन को Submit करने मात्र से आवेदन भरा हुआ नहीं माना जावेगा। आवेदन Submit करने के बाद फीस जमा होने पर ही ऑनलाईन आवेदन भरा हुआ माना जायेगा। यदि आवेदन Submit करने एवं फीस जमा कराने के बाद भी यदि आवेदन पर Transaction Failed आ रहा है तो आवेदन भरा हुआ नहीं माना जावेगा। ऐसी स्थिति में ई-मित्र हेल्पलाइन नम्बर 0141-2221424 / 2221425 पर सम्पर्क करें। ऑनलाईन आवेदन संबंधी समस्याओं के लिये हेल्पलाइन नम्बर 0294-3057541 पर सम्पर्क करें। उपरोक्त प्रक्रिया से आवेदक स्वयं भी ऑनलाईन आवेदन भर सकता है।

अभ्यर्थी अपने SSO ID एवं password से Login करेंगे। इसके पश्चात् Dashboard पर Ongoing Recruitment पर संबंधित परीक्षा के Apply now link पर Click कर अपना आवेदन भरेगा। आवेदन पूर्ण रूप से भरने के बाद Next पर Click करने पर Application preview Page खुलेगा। अभ्यर्थी स्वयं अपने द्वारा भरे गये आवेदन की पुनः गहनता से जांच कर ले तथा यदि कोई

Page | 1

त्रुटि रह जाती है तो अभ्यर्थी Update पर Click करके अपने आवेदन में संशोधन कर त्रुटियों को सही कर सकता है। त्रुटियों को सुधारने के बाद आवेदक पुनः अपने आवेदन का Preview देख कर यह सुनिश्चित कर ले कि उनके द्वारा आवेदन पत्र में भरी गई समस्त प्रविष्टियाँ पूर्ण रूप से सही हैं। अभ्यर्थी सही-सही आवेदन भरने के बाद Submit पर Click कर अपना आवेदन भरेगा। आवेदक अपना आवेदन Submit करने के बाद OK पर Click करेंगे। इसके बाद आवेदन में कोई संशोधन नहीं किया जा सकेगा। OK पर Click करने के बाद Pay Fees का Page खुलेगा। अभ्यर्थी अपनी श्रेणी के अनुसार परीक्षा शुल्क नेट बैंकिंग/ए.टी.एम. कम डेबिट कार्ड/क्रेडिट कार्ड/ई-मित्र के माध्यम से जमा करवा सकता है। आवेदन भरने के बाद अभ्यर्थी आवेदन की हार्ड कॉपी मय रसीद आवश्यक रूप से प्राप्त करें। यदि आवेदन Submit करने एवं फीस जमा कराने के बाद भी यदि आवेदन पर Transaction Failed आ रहा है तो आवेदन भरा हुआ नहीं माना जायेगा। ऐसी स्थिति में ई-मित्र हेल्पलाइन नम्बर 0141-2221424 / 2221425 पर सम्पर्क करें। ऑनलाइन आवेदन संबंधी समस्याओं के लिये हेल्पलाइन नम्बर 0294-3057541 पर सम्पर्क करें। आवेदन की रसीद अभ्यर्थी को ई-मेल/एसएमएस के माध्यम से प्राप्त होगी। हाथ से भरे आवेदन-पत्र किसी भी रूप से चयन बोर्ड द्वारा स्वीकार नहीं किये जावेंगे।

नोट:-

1. शासन सचिवालय, राजस्थान लोक सेवा आयोग एवं प्रशासनिक सुधार विभाग के माध्यम से राज्य सरकार के अधीनस्थ विभागों/कार्यालयों के लिये शीघ्रलिपिक के पदों पर चयनित अभ्यर्थियों को उक्त विभागों का आवंटन वरियता सह प्राथमिकता (Merit cum Priority) के आधार पर किया जावेगा। अतः ऑनलाइन आवेदन प्रस्तुत करते समय अभ्यर्थी जिन विभागों में पदस्थापन चाहते हैं उन विभागों का प्राथमिकता क्रम पद कोड संख्या के अनुसार अवश्य भरें। अन्यथा उनको विभागों का आवंटन बोर्ड द्वारा अपने स्तर पर वरियता के आधार पर पद कोड संख्या के अनुसार किया जायेगा। प्रशासनिक सुधार विभाग को उनकी अर्चना में वर्णित 1010 रिक्त पदों के विरुद्ध चयनित अभ्यर्थी बोर्ड द्वारा उपलब्ध करवाये जायेंगे। चयनित अभ्यर्थियों को विभागों का आवंटन प्रशासनिक सुधार विभाग द्वारा किया जायेगा।
2. आवेदक अपना ऑनलाइन आवेदन पत्र अंतिम रूप से भरने से पूर्व उसकी प्रविष्टियों से आश्वस्त हो लें कि सभी प्रविष्टियाँ सही-सही भरी गई हैं। आवेदक द्वारा आवेदन में भरी गई प्रविष्टियों को ही सही मानकर आगे की कार्यवाही की जावेगी। आवेदक आवेदन पत्र को ध्यानपूर्वक भरें।
3. अभ्यर्थी ऑनलाइन आवेदन भरने के उपरान्त रसीद आवश्यक रूप से प्राप्त कर लें।
4. आवेदक यह ध्यान दें कि ऑनलाइन आवेदन के उपरान्त उन्हें आवेदन-पत्र कर्मांक आवश्यक रूप से उपलब्ध होगा और यदि आवेदन-पत्र कर्मांक (एप्लीकेशन आई.डी.) अंकित या प्राप्त नहीं हुआ है, तो इसका अर्थ यह है कि उसका आवेदन-पत्र जमा नहीं हुआ है। आवेदक आवेदन प्रपत्र के preview को आवेदन submit न मानें।
5. कृपया ऑनलाइन आवेदन-पत्र भरने से पूर्व बोर्ड की वेबसाइट पर उपलब्ध इस विज्ञापित एवं अभ्यर्थियों के लिये आवेदन व परीक्षा संबंधी सामान्य दिशा-निर्देशों का ध्यान पूर्वक अध्ययन कर लें। इस विज्ञापित एवं उक्त दिशा-निर्देशों को ध्यान में रखकर ही ऑनलाइन आवेदन भरें।

2. परीक्षा शुल्क:-आवेदक अपनी श्रेणी के अनुरूप निम्नानुसार परीक्षा शुल्क राज्य के निर्धारित ई-मित्र कियोस्क या जन सुविधा केन्द्र (C.S.C.) के माध्यम से चयन बोर्ड को भेजे।

- (क) सामान्य वर्ग व कीमीलेयर श्रेणी के अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग के आवेदक हेतु -रुपये 450/-
 (ख) राजस्थान के नॉन कीमलेयर श्रेणी के पिछड़ा वर्ग/अति पिछड़ा वर्ग के आवेदक हेतु -रुपये 350/-
 (ग) समस्त विशेष योग्यजन तथा राजस्थान के अनुसूचित जाति/अनुसूचित जनजाति के आवेदक हेतु -रुपये 250/-
 (घ) कार्मिक विभाग के परिपत्र कर्मांक प.8(3) कार्मिक/क-2/18 दिनांक 02.05.2018 के अनुसार सभी वर्ग के ऐसे अभ्यर्थी, जिनके परिवार की वार्षिक आय 2.50 लाख रुपये से कम है, के लिये अनुसूचित जाति/अनुसूचित जनजाति के समान ही परीक्षा शुल्क रुपये 250/- देय है। (कृपया इस संबंध में नीचे अंकित नोट संख्या 5 भी अवश्य देखें।)

नोट:-

1. आवेदकों की सुविधा के लिये राज्य के समस्त ई-मित्र कियोस्क तथा जन सुविधा केन्द्र (C.S.C) की सूची बोर्ड की वेबसाइट पर उपलब्ध है।
2. राजस्थान राज्य से भिन्न राज्यों के अनुसूचित जाति/अनुसूचित जनजाति/अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग के अभ्यर्थियों को सामान्य वर्ग का अभ्यर्थी माना जायेगा। अतः ऐसे आवेदकों को सामान्य अभ्यर्थियों के लिए निर्धारित परीक्षा शुल्क देना होगा।
3. फीस एक बार जमा होने पर वापिस नहीं लौटाई जायेगी।
4. फीस जिस श्रेणी की जमा कराई जाती है, अभ्यर्थी को उसी श्रेणी का माना जायेगा। बाद में अभ्यर्थी की श्रेणी में सामान्यतः परिवर्तन नहीं किया जायेगा।
5. सभी वर्ग के ऐसे अभ्यर्थी, जिनके परिवार की वार्षिक आय 2.50 लाख रुपये से कम है तथा वे परीक्षा शुल्क रुपये 250/- ही जमा कराते हैं, ऐसे अभ्यर्थी अपने परिवार की वार्षिक आय 2.50 लाख रुपये से कम होने का सक्षम प्राधिकारी द्वारा जारी आय प्रमाण-पत्र पात्रता की जांच एवं दस्तावेज के सत्यापन के समय आवश्यक रूप से प्रस्तुत करना होगा।

3. **प्रवेश पत्र:**—बोर्ड द्वारा समस्त अभ्यर्थियों को बोर्ड की वेबसाईट के माध्यम से ही ऑनलाईन प्रवेश-पत्र जारी किये जाएंगे। बोर्ड द्वारा डाक से कोई भी प्रवेश पत्र नहीं भेजा जाएगा। बोर्ड की वेबसाईट पर प्रवेश-पत्र जारी किये जाने की सूचना समाचार पत्रों एवं वेबसाईट के माध्यम से जारी की जाएगी। आवेदक अपना प्रवेश-पत्र वेबसाईट से प्राप्त करने हेतु आवेदन पत्र कर्मांक एवं जन सुविधा (C.S.C) पर फीस जमा कराने का टोकन नम्बर ध्यान में रखे। उपलब्ध संसाधनों एवं सुविधा के आधार पर प्रवेश-पत्र सम्बन्धी सूचना आवेदक के ई-मेल आईडी (E-mail ID) एवं मोबाइल नम्बर पर भेजी जा सकती है। अतः आवेदकों को सलाह दी जाती है कि वे आवेदन पत्र में अपना ही मोबाइल नम्बर दर्ज करें तथा मोबाइल नम्बर नहीं बदलें।

4. शीघ्रलिपिक के रिक्त पदों का वर्गवार आरक्षण निम्न प्रकार है:-

(क) शीघ्रलिपिक (शासन सचिवालय) पद कोड संख्या-01

कुल पद	सामान्य				अनुसूचित जाति				अनुसूचित जनजाति				पिछड़ा वर्ग				अति पिछड़ा वर्ग			
	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित
70	26	08	02	-	06	03	-	-	06	02	-	-	10	03	01	-	01	-	-	-

क्षेत्रीय आरक्षण (Horizontal)					
विशेष योग्यजन			शासन सचिवालय में कार्यरत (लिपिक ग्रेड-II व लिपिक ग्रेड-I)		उत्कृष्ट खिलाड़ी
B/LV	HI	LD & CP			
01	01	-	35		08

(ख) शीघ्रलिपिक (राजस्थान लोक सेवा आयोग) पद कोड संख्या-02

कुल पद	सामान्य				अनुसूचित जाति				अनुसूचित जनजाति				पिछड़ा वर्ग				अति पिछड़ा वर्ग			
	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित	सामान्य	सामान्य महिला	श्रद्धा	परिवर्तित
05	3	1	-	-	-	-	-	-	-	-	-	-	01	-	-	-	-	-	-	-

क्षेत्रीय आरक्षण (Horizontal)					
विशेष योग्यजन			राजस्थान लोक सेवा आयोग में कार्यरत (लिपिक ग्रेड-II व लिपिक ग्रेड-I)		उत्कृष्ट खिलाड़ी
B/LV	HI	LD & CP			
01	-	-	02		-

(ग) शीघ्रलिपिक (राज्य के अधीनस्थ विभागों/कार्यालयों) (गैर अनुसूचित क्षेत्र) पद कोड संख्या-03

कुल पद	सामान्य				अनुसूचित जाति				अनुसूचित जनजाति				पिछड़ा वर्ग				अति पिछड़ा वर्ग			
	सामान्य	सामान्य महिला	विधवा	परिव्रता	सामान्य	सामान्य महिला	विधवा	परिव्रता	सामान्य	सामान्य महिला	विधवा	परिव्रता	सामान्य	सामान्य महिला	विधवा	परिव्रता	सामान्य	सामान्य महिला	विधवा	परिव्रता
958	366	105	41	10	112	33	12	03	84	25	09	02	108	31	12	03	0	0	0	0

क्षेत्रीय आरक्षण (Horizontal)				
विशेष योग्यजन			भूतपूर्व सैनिक	उत्कृष्ट खिलाड़ी
B/LV	HI	LD/CP		
04	04	04	33	02

(घ) शीघ्रलिपिक(राज्य के अधीनस्थ विभागों/कार्यालयों) (अनुसूचित क्षेत्र) पद कोड संख्या-03

कुल पद	सामान्य				अनुसूचित जाति				अनुसूचित जनजाति			
	सामान्य	सामान्य महिला	विधवा	परिव्रता	सामान्य	सामान्य महिला	विधवा	परिव्रता	सामान्य	सामान्य महिला	विधवा	परिव्रता
52	24	07	02	—	07	02	—	—	07	03	—	—

क्षेत्रीय आरक्षण (Horizontal)				
विशेष योग्यजन			भूतपूर्व सैनिक	उत्कृष्ट खिलाड़ी
B/LV	HI	LD/CP		
—	—	01	—	—

नोट:-

1. गैर अनुसूचित क्षेत्र की रिक्तियों के विरुद्ध अनुसूचित क्षेत्र के निवासी भी आवेदन कर सकेंगे।
2. महिला, भूतपूर्व सैनिकों, उत्कृष्ट खिलाड़ी, विशेष योग्यजन, राजस्थान लोक सेवा आयोग एवं शासन सचिवालय में कार्यरत (लिपिक ग्रेड-II व लिपिक ग्रेड-I) के लिए आरक्षित पदों का आरक्षण क्षैतिज (Horizontal) होगा।
3. राजस्थान लोक सेवा आयोग एवं शासन सचिवालय में कार्यरत (लिपिक ग्रेड-II व लिपिक ग्रेड-I) के लिए संबंधित विभाग के पदों के आरक्षित पदों में नियमानुसार 50 प्रतिशत पद आरक्षित किये गये हैं।
4. आरक्षण की स्थिति एवं नियुक्ति प्रक्रिया राज्य सरकार के निर्देशों एवं नवीनतम नियमों के अधीन परिवर्तनीय होगी।
5. विज्ञापन जारी होने के उपरान्त विज्ञापित पदों की संख्या में कमी या बढ़ोतरी की जाती है तो इसके लिये अलग से कोई सूचना/शुद्धि पत्र जारी नहीं किया जायेगा।
6. कार्मिक(क-2) विभाग के परिपत्र क्रमांक प.13(20) कार्मिक/क-2/91/पार्ट-3 दिनांक 01.06.2018 एवं भारत सरकार के विधि एवं न्याय मंत्रालय (विधायी विभाग) की अधिसूचना दिनांक 19.05.2018 के क्रम में प्रशासनिक सुधार विभाग के माध्यम से प्राप्त राज्य के अधीनस्थ विभागों/कार्यालयों के लिये विज्ञापित पदों में गैर अनुसूचित क्षेत्र एवं अनुसूचित क्षेत्र के लिये आरक्षित पदों की संख्या में परिवर्तन हो सकता है। पदों में परिवर्तन होने की स्थिति में इस हेतु सूचना/शुद्धि पत्र अलग से जारी कर दिया जायेगा।

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विशेष सूचना:-

1. कार्मिक (क-2) विभाग की अधिसूचना दिनांक 17.01.2013 के अनुसार किसी वर्ष विशेष में सीधी भर्ती के लिए राजस्थान के अनुसूचित जाति/अनुसूचित जनजातियों के पात्र एवं उपयुक्त अभ्यर्थी उपलब्ध नहीं होने की दशा में उनके लिए इस प्रकार आरक्षित रिक्तियों को पश्चात्तर्ती तीन भर्ती वर्षों के लिए अग्रणीत किया जायेगा। तीन भर्ती वर्षों की समाप्ति के पश्चात ऐसी अग्रणीत की गई रिक्तियां सामान्य प्रक्रिया के अनुसार भरी जायेगी।
परन्तु यदि किसी भर्ती वर्ष में भर्ती नहीं की जाती है तो ऐसे भर्ती वर्ष को इस उप-नियम के प्रयोजन के लिए संगणित नहीं किया जाएगा।
परन्तु यह और कि इस उप-नियम के अधीन सामान्य प्रक्रिया के अनुसार रिक्तियों का भरा जाना पद आधारित रोस्टर के अनुसार पदों के आरक्षण को प्रभावित नहीं करेगा और रोस्टर में आरक्षित पदों पर उपलब्ध रिक्तियों को अनुसूचित जातियों या, यथास्थिति, अनुसूचित जनजातियों के व्यक्तियों में से भरा जा सकेगा जिनके लिये ऐसी रिक्ति पश्चात्तर्ती वर्षों में उपलब्ध हो।
2. राजस्थान के अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग के आरक्षित पदों हेतु पात्र एवं उपयुक्त आवेदक उपलब्ध नहीं होने पर इन पदों को नियमानुसार सामान्य प्रक्रिया से भरा जाएगा।
3. महिलाओं हेतु रिक्तियों का आरक्षण क्षैतिज (Horizontal) प्रवर्गानुसार (Categorywise) 30 प्रतिशत होगा। महिला अभ्यर्थियों का आरक्षण उस संबंधित प्रवर्ग में जिनकी वे महिला आवेदक हैं, आनुपातिक रूप से समायोजित किया जाएगा।
स्पष्टीकरण:- किसी वर्ग (अनारक्षित पद (सामान्य वर्ग)/अनुसूचित जाति/अनुसूचित जनजाति/अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग) की पात्र एवं उपयुक्त महिला आवेदक उपलब्ध नहीं होने पर उस पद को उसी वर्ग के पुरुष आवेदक से भरा जाएगा। विवाहित महिला आवेदक को अपने पिता के नाम, निवास स्थान एवं आय के आधार पर जारी अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग का नॉन क्रीमीलेयर का प्रमाण पत्र प्रस्तुत करना होगा। पति के नाम व आय के आधार पर जारी प्रमाण पत्र मान्य नहीं होगा।
4. महिलाओं हेतु आरक्षित दर्शाए गए पदों में नियमानुसार 8 प्रतिशत पद विधवा एवं 2 प्रतिशत परित्यक्ता (विवाह विछिन्न महिला) महिलाओं के लिए आरक्षित है। यदि पर्याप्त विधवा अभ्यर्थी उपलब्ध नहीं होती है तो विधवा के लिये आरक्षित पद को उसी श्रेणी की परित्यक्ता (विवाह -विछिन्न महिला) से भरा जायेगा। इसी प्रकार यदि पर्याप्त परित्यक्ता अभ्यर्थी उपलब्ध नहीं होती है तो इनके लिये आरक्षित पद को उसी श्रेणी की विधवा महिला से भरा जायेगा। यदि विधवा एवं परित्यक्ता दोनों ही पर्याप्त संख्या में उपलब्ध नहीं होती है तो इनके लिये आरक्षित पद को उसी श्रेणी की सामान्य महिला से भरा जायेगा। विधवा आवेदक होने की स्थिति में सक्षम प्राधिकारी द्वारा जारी पति की मृत्यु का प्रमाण-पत्र एवं परित्यक्ता महिला (विवाह विछिन्न महिला) को भी विवाह विच्छेद का प्रमाण प्रस्तुत करना होगा।
5. अति पिछड़ा वर्ग के लिये राज्य सरकार की अधिसूचना क्रमांक एफ.7(2)/डीओपी/ए-11/2017 दिनांक 21.12.2017 के अनुसार राजस्थान राज्य के अति पिछड़ा वर्ग की जातियों (नॉन क्रीमीलेयर) को 1 प्रतिशत आरक्षण देय है।
6. कार्मिक (क-2) विभाग के परिपत्र दिनांक 26.07.2017 के अनुसार सामान्य श्रेणी के पदों के विरुद्ध चयन हेतु आरक्षित वर्ग (अनुसूचित जाति/ अनुसूचित जनजाति/ अन्य पिछड़ा वर्ग/ अति पिछड़ा वर्ग) के केवल वे ही आवेदक पात्र होंगे जिन्होंने शुल्क के अतिरिक्त आरक्षित श्रेणी के लिये देय किसी अन्य रियायत का लाभ नहीं उठाया है।
7. राजस्थान राज्य से भिन्न अन्य राज्यों के अनुसूचित जाति/अनुसूचित जनजाति/अन्य पिछड़ा एवं अति पिछड़ा वर्ग के अभ्यर्थियों को सामान्य वर्ग का माना जावेगा।
8. बारा जिले की सहरिया आदिम जाति के आवेदक को आवेदन पत्र में अपनी श्रेणी के संबंधित कॉलम में स्पष्ट रूप से अंकन करने पर ही उन्हें बारा जिले में सहरिया जाति के लिये राज्य सरकार के निर्देश क्रमांक प.13(20) कार्मिक/क-2/91पार्ट दिनांक 21.05.2013 के अनुसार आरक्षण का लाभ देय होगा।
9. भूतपूर्व सैनिकों हेतु:- भूतपूर्व सैनिकों को आरक्षण राजस्थान सिविल सेवा (भूतपूर्व सैनिकों का आमेसन) नियम, 1988 के प्रावधानों के अनुसार भूतपूर्व सैनिकों के लिए 12.5 प्रतिशत पद आरक्षित है। भूतपूर्व सैनिक के पदों का आरक्षण क्षैतिज (Horizontal) रूप से है अर्थात् आवेदक जिस वर्ग (सामान्य वर्ग/अनुसूचित जाति/अनुसूचित जनजाति/पिछड़ा वर्ग/अति पिछड़ा वर्ग) का उपलब्ध होगा उसे उसी वर्ग के अन्तर्गत समायोजित किया जाएगा। उपयुक्त भूतपूर्व सैनिकों की अनुपलब्धता के कारण इन पदों को नियमानुसार सामान्य प्रक्रिया से भरा जा सकेगा। भूतपूर्व सैनिकों के लिये कार्मिक विभाग की अधिसूचना क्रमांक एफ.5(18) कार्मिक/क-2/84 पार्ट-11 दिनांक 17.04.2018 के अनुसार प्रावधान भी लागू होंगे।
10. उत्कृष्ट खिलाड़ी के पदों हेतु:- उत्कृष्ट खिलाड़ियों को आरक्षण राज्य सरकार की अधिसूचना क्रमांक F.5(31)DOP/A-11/84 दिनांक 15.03.2013 के अनुसार कुल रिक्तियों का 2% देय होगा। उत्कृष्ट खिलाड़ी हेतु आरक्षित पदों का आरक्षण क्षैतिज (Horizontal) रूप से है अर्थात् आवेदक जिस वर्ग (सामान्य वर्ग/अनुसूचित जाति/अनुसूचित जनजाति/पिछड़ा वर्ग/अति पिछड़ा वर्ग) का होगा उसे उसी वर्ग के अन्तर्गत समायोजित किया जाएगा। इस आरक्षित पद हेतु पात्र एवं उपयुक्त आवेदक उपलब्ध नहीं होने पर इस पद को नियमानुसार सामान्य प्रक्रिया से भरा जाएगा और ऐसी रिक्ति पश्चात्तर्ती वर्ष के लिए अग्रणीत नहीं की जाएगी। उत्कृष्ट खिलाड़ी श्रेणी में केवल वे ही अभ्यर्थी आवेदन करें जो कार्मिक विभाग द्वारा जारी अधिसूचना क्रमांक एफ.5(31)डीओपी/ए-11/84 दिनांक 15-03-2013 में नीचे वर्णित योग्यता रखता हो। इनसे भिन्न योग्यता रखने वाले अभ्यर्थी का उत्कृष्ट खिलाड़ियों के लिये आरक्षित पदों पर चयन पर विचार नहीं किया जायेगा।

उत्कृष्ट खिलाड़ी सम्बन्धी प्रावधान :- कार्मिक विभाग द्वारा जारी अधिसूचना क्रमांक एफ5(31)डीओपी/ए-11/84 दिनांक 15-03-2013 के तहत किये गये संशोधन के अनुसार "उत्कृष्ट खिलाड़ियों" से अभिप्रेत है और इसमें सम्मिलित हैं, राज्य के ऐसे खिलाड़ी जिन्होंने :-

1. इण्डियन ओलम्पिक एसोसिएशन या संबंधित मान्यता प्राप्त नेशनल स्पोर्ट्स फेडरेशन द्वारा मान्यता प्राप्त किसी खेलकूद के कोई अन्तर्राष्ट्रीय टूर्नामेंट में व्यक्तिशः या टीम स्पर्धा में भारतीय टीम का प्रतिनिधित्व किया हो।
या
2. इण्डियन स्कूल स्पोर्ट्स फेडरेशन या संबंधित मान्यता प्राप्त नेशनल स्कूल गेम्स फेडरेशन द्वारा मान्यता प्राप्त किसी खेलकूद के कोई अन्तर्राष्ट्रीय टूर्नामेंट में व्यक्तिशः या टीम स्पर्धा में भारतीय टीम का प्रतिनिधित्व किया हो।
या
3. इण्डियन ओलम्पिक एसोसिएशन या संबंधित मान्यता प्राप्त नेशनल स्पोर्ट्स फेडरेशन द्वारा मान्यता प्राप्त किसी खेलकूद के कोई राष्ट्रीय टूर्नामेंट में व्यक्तिशः या टीम स्पर्धा में मेडल जीता हो।
या
4. इण्डियन यूनिवर्सिटीज एसोसिएशन द्वारा मान्यता प्राप्त किसी खेलकूद के ऑल इण्डिया इंटरयूनिवर्सिटी टूर्नामेंट में व्यक्तिगत स्पर्धा में या टीम स्पर्धा में मेडल जीता हो।

कृपया ध्यान दें कि यदि किसी आवेदक ने जान-बूझकर बिना साक्ष्य गलत आरक्षण श्रेणी अंकित की है, तो बोर्ड द्वारा आवेदक के विरुद्ध कार्यवाही भी की जा सकती है।

11 विशेष योग्यजन (निःशक्तजन) के लिये :-

- a. राजस्थान निःशक्तजन व्यक्तियों का (समान अवसर, अधिकारों का संरक्षण और पूर्ण भागीदारी) नियम, 2011 के अनुसार निःशक्तजन श्रेणी में निम्न श्रेणियों को ही शौचालयिक पदों हेतु आरक्षण का लाभ देय है :-
 1. B/LV (Blind and Low Vision)
 2. HI (Hearing Impairment)
 3. LD/CP (Locomotor Disability and Cerebral Palsy)
विशेष योग्यजन के लिये दर्शाए गए आरक्षित पदों का आरक्षण भी क्षैतिज (Horizontal) रूप से है अर्थात् अभ्यर्थी जिस वर्ग (सामान्य वर्ग/अनुसूचित जाति/अनुसूचित जनजाति/अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग) का होगा उसे उसी वर्ग के अन्तर्गत समायोजित किया जाएगा।
- b. उपरोक्त दर्शाए गए विशेष योग्यजन के आरक्षित पदों के लिए पात्र एवं उपयुक्त अभ्यर्थी उपलब्ध नहीं होने की स्थिति में इन पदों को राजस्थान निःशक्तजन व्यक्तियों का (समान अवसर अधिकार व संरक्षण और पूर्ण भागीदारी) नियम, 2011 के अनुसार भरा जायेगा। विशेष योग्यजन के उक्त नियम के नियम 38(4) के अनुरूप उपरोक्त विशेष योग्यजनों की अनुपलब्धता के कारण अन्य किसी भी पर्याप्त कारण से पद भरा नहीं जा सकता तो वहाँ ऐसी स्थिति को अग्रणीत किया जाएगा।
- c. विशेष योग्यजन आवेदक On line application form में सधारस्थान अपने वर्ग एवं विशेष योग्यजन की श्रेणी विशेष का अवश्य उल्लेख करें।
- d. ऐसे आवेदक जो विशेष योग्यजन की श्रेणी में आते हैं, अपनी विशेष योग्यजन के सम्बन्ध में राजस्थान निःशक्तजन व्यक्तियों का (समान अवसर, अधिकारों का संरक्षण और पूर्ण भागीदारी) नियम, 2011 के नियम 2(1)(b) के अनुसार समुचित सरकार द्वारा निर्धारित चिकित्सा प्राधिकारी के द्वारा प्रदत्त स्थाई विशेष योग्यजन प्रमाण पत्र (Permanent Disability Certificate) में विशेष योग्यजन का स्पष्ट प्रमाण-पत्र प्रस्तुत करना होगा। राजस्थान निःशक्तता व्यक्तियों के नियोजन नियम के अनुसार मेडिकल बोर्ड द्वारा प्रदत्त निःशक्तता (विशेष योग्यजन) का प्रमाण पत्र जो 40 प्रतिशत या इससे अधिक विशेष योग्यजन होने पर ही अभ्यर्थी को विशेष योग्यजनों हेतु आरक्षित पदों हेतु पात्र माना जाए।

5. अनुसूचित क्षेत्र के अभ्यर्थियों के लिए विशेष निर्देश :-

1. अनुसूचित क्षेत्र के लिए अनुसूचित जनजाति एवं अनुसूचित जाति आरक्षण की गणना राज्य सरकार की अधिसूचना संख्या एफ. 13(20) कार्मिक/क-2/91/पार्ट दिनांक 04.07.2018 एवं परिपत्र क्रमांक प.13(20) कार्मिक/क-2/91/पार्ट-3 दिनांक 01.06.2018 द्वारा भारत सरकार के विधि एवं न्याय मंत्रालय (विधायी विभाग) की अधिसूचना दिनांक 19.05.2018 के अनुसार की जायेगी।
2. अनुसूचित क्षेत्र के लिए कार्मिकों का चयन राजस्थान अनुसूचित क्षेत्र अधीनस्थ, मंत्रालयिक एवं चतुर्थ श्रेणी सेवा (भर्ती एवं अन्य सेवा शर्तों) नियम-2014 के अनुसार होगा। जहां पर इन नियमों में स्पष्ट प्रावधान नहीं है, वहां पर राजस्थान अधीनस्थ एवं मंत्रालयिक सेवा नियम-1999 यथा संशोधित के प्रावधान लागू होंगे।
3. अनुसूचित क्षेत्र भारत के राष्ट्रपति, द्वारा समय-समय पर यथा संशोधित अधिसूचना संख्या एफ. 19(2) 80-एल-1 दिनांक 12.02.1981 द्वारा घोषित क्षेत्र के क्रम में कार्मिक(क-2) विभाग ने अपने परिपत्र क्रमांक प.13(20) कार्मिक/क-2/91/पार्ट-3 दिनांक 01.06.2018 द्वारा भारत सरकार के विधि एवं न्याय मंत्रालय (विधायी विभाग) की अधिसूचना दिनांक 19.05.2018 (बोर्ड की वेबसाइट पर उपलब्ध) के द्वारा अनुसूचित क्षेत्र को विखण्डित (Rescinds) करते हुए, अनुसूचित क्षेत्रों को पुनः परिनिश्चित

(Redefined) किया गया है। अनुसूचित क्षेत्र के आवेदकों को सलाह दी जाती है कि वे नवीनतम अधिसूचना में शामिल अनुसूचित क्षेत्रों को ध्यान में रखते हुए ही अनुसूचित क्षेत्र के कॉलम में ऑनलाईन आवेदन प्रस्तुत करें।

नोट:- अनुसूचित क्षेत्र के अभ्यर्थियों के लिए वेतनमान, पात्रता एवं शैक्षणिक योग्यता, राष्ट्रीयता, आयु, पेंशन, विवाह पंजीयन, परीक्षा शुल्क जमा कराने एवं ऑनलाईन आवेदन भरने, नियुक्ति की अयोग्यताएं, प्रमाण-पत्रों के सत्यापन, अनुचित साधनों की रोकथाम, ऑनलाईन आवेदन में संशोधन की प्रक्रिया एवं परीक्षा का पाठ्यक्रम एवं स्कीम संबंधी प्रावधान गैर-अनुसूचित क्षेत्र के समान यथावत लागू होंगे।

6. वेतनमान:- राज्य सरकार द्वारा देय सातवें वेतनमान के अनुसार वेतनमान निम्नानुसार है :-

क्र.सं.	पद का नाम	पे-मैट्रिक्स लेवल
1.	शीघ्रलिपिक	L-10

परीक्षा काल में मासिक नियत पारिश्रमिक राज्य सरकार के आदेशानुसार देय होगा।

7. पात्रता एवं शैक्षणिक योग्यता:-

- (i) Senior Secondary from a recognized Board or its equivalent Examination.
AND
(ii) "O" or Higher Level certificate course conducted by DOEACC under control of the Department of Electronics, Government of India.
OR
Certificate course on computer concept by NIELIT, New Delhi.
OR
Computer operator & Programming Assistant (COPA)/Data Preparation and computer software (DPCS) certificate organized under National/ State council or Vocational Training Scheme.
OR
Degree/ Diploma/Certificate in Computer Science / Computer application from a university established by law in India or from an institution recognized by the Government.
OR
Senior Secondary Certificate from a recognized Board of Secondary Education in the Country, with the computer Science/ Computer Application as one of the subjects.
OR
Diploma in computer Science & Engineering from a polytechnic institution recognized by the Government.
OR
Rajasthan State Certificate Course in Information Technology (RSCIT) conducted by Vardhman Mahaveer Open University, Kota under control of Rajasthan Knowledge Corporation Limited".
(iii) देवनागरी लिपी में लिखी हिन्दी में कार्य करने का ज्ञान एवं राजस्थान की संस्कृति का ज्ञान।

आवश्यक नोट:-परन्तु ऐसा व्यक्ति, जो सीधी भर्ती हेतु नियमों या अनुसूचियों में यथा उल्लिखित पद के लिए अपेक्षित शैक्षणिक अर्हता वाले ऐसे पाठ्यक्रम के अन्तिम वर्ष की परीक्षा में उपस्थित हो चुका/चुकी है या उपस्थित हो रहा /रही है, उस पद के लिए आवेदन करने का पात्र होगा/होगी किन्तु उसे -

1. जहां चयन लिखित परीक्षा एवं साक्षात्कार के दो प्रक्रमों के माध्यम से किया जाता हो, मुख्य परीक्षा में उपस्थित होने से पूर्व,
 2. जहां चयन लिखित परीक्षा एवं साक्षात्कार के माध्यम से किया जाता हो, साक्षात्कार में उपस्थित होने से पूर्व,
 3. जहां चयन केवल लिखित परीक्षा या यथास्थिति, केवल साक्षात्कार के माध्यम से किया जाता हो, लिखित परीक्षा अथवा साक्षात्कार में उपस्थित होने से पूर्व,
- समुचित चयन एजेन्सी/बोर्ड को अपेक्षित शैक्षणिक अर्हता अर्जित कर लेने का सबूत प्रस्तुत करना होगा।

नोट:-

1. आवेदकों को शीघ्रलिपिक के पद पर निर्धारित शैक्षणिक योग्यता परीक्षा के फेज- II की हिन्दी/अंग्रेजी की आशुलिपि (Shorthand) परीक्षा की अंतिम तिथि से पूर्व तक अर्जित करना अनिवार्य है।

अन्य योग्यताएँ :-

- (1) स्वास्थ्य :- शीघ्रलिपिक के पदों पर भर्ती के लिए उम्मीदवार अच्छे मानसिक और शारीरिक स्वास्थ्य का होना चाहिए और वह ऐसे किसी मानसिक या शारीरिक दोष से मुक्त होना चाहिए जो कि उक्त पदों के रूप में उसके कर्तव्यों के कुशल पालन में बाधा डाल सके और यदि वह चयनित कर लिया जाता है तो उसे इसके लिये अपना आरोग्यता प्रमाण पत्र उस जिले के मुख्य चिकित्सा एवं स्वास्थ्य अधिकारी या मेडीकल ज्यूरिस्ट द्वारा हस्ताक्षरित प्रस्तुत करना होगा जिस जिले में सामान्यतः वह निवास करता है।
- (2) चरित्र :- सेवा में सीधी भर्ती के लिए आवेदक का चरित्र ऐसा होना चाहिये जिससे कि वह शीघ्रलिपिक पदों पर नियुक्ति के लिये योग्य हो सके। उसे सद्चरित्र का प्रमाण पत्र ऐसे विश्वविद्यालय, स्कूल या कॉलेज जहाँ उसने अंतिम शिक्षा प्राप्त की हो, के प्रधानाचार्य / शिक्षा अधिकारी के द्वारा प्रदत्त, प्रस्तुत करना होगा और दो ऐसे उत्तरदायी व्यक्तियों के प्रमाण पत्र भी प्रस्तुत करने होंगे जो आवेदन-पत्र की दिनांक से 6 महीने पहले के न हो और अभ्यर्थी के रिश्तेदार द्वारा दिये हुये नहीं हो।

8. राष्ट्रीयता :-

- (क) भारत का नागरिक हो, या
 - (ख) नेपाल का प्रजाजन हो, या
 - (ग) भूटान का प्रजाजन हो, या
 - (घ) ऐसा तिब्बती शरणार्थी जो दिनांक 1-1-62 से पहले भारत में स्थाई रूप से बसने के विचार से आया था, या
 - (ङ) भारतीय मूल का व्यक्ति ने जो भारत में स्थाई रूप से बसने के विचार से पाकिस्तान, बर्मा, श्रीलंका, पूर्वी अफ्रीकी देश कीनिया, युगान्डा और संयुक्त तंजानिया गणराज्य (भूतपूर्व टंगानिया तथा जंजीबार), जाम्बिया, मालवी, जैर और इथोपिया से भारत में स्थानान्तरण कर लिया हो।
- नोट:-परन्तु शर्त यह है कि वर्ग (ख),(ग),(घ),(ङ) से सम्बन्धित प्रार्थियों को भारत सरकार के गृह एवं न्याय विभाग द्वारा प्रदत्त पात्रता का वांछित प्रमाण-पत्र प्रस्तुत करना होगा।

9. आयु:-

आवेदक 1, जनवरी 2019 को 18 वर्ष की आयु प्राप्त कर चुका हो तथा 40 वर्ष का नहीं हुआ हो, परन्तु राज्य सरकार की अधिसूचना क्रमांक एफ.7/6/कार्मिक/क-II/2008 दिनांक 23.09.2008 के अनुसार "जिस भर्ती वर्ष विशेष में सीधी भर्ती के पदों के लिये भर्ती नहीं हुई हो और यदि कोई आवेदक उस वर्ष की भर्ती में आयु की दृष्टि से पात्र था तो उसे आयु की दृष्टि से पात्र माना जावेगा, किन्तु यह छूट 3 वर्ष से अधिक नहीं दी जायेगी।"

स्पष्टीकरण:- शीघ्रलिपिक पदों पर भर्ती परीक्षा का आयोजन विगत 03 वर्ष में नहीं होने के कारण समस्त आवेदकों को अधिकतम आयु सीमा में 3 वर्ष की और छूट दी जाएगी।

उच्चतम आयु सीमा में अन्य विशेष श्रेणियों में छूट निम्न प्रकार देय होगी:-

1. आयु सीमा में छूट के प्रावधान :-

- (क) सामान्य वर्ग की महिला अभ्यर्थियों के मामले में 5 वर्ष की छूट दी जायेगी।
- (ख) अनुसूचित जाति/अनुसूचित जनजाति/अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग के पुरुष अभ्यर्थियों को जो राजस्थान के स्थायी निवासी हैं, के मामले में 5 वर्ष की छूट दी जायेगी।
- (ग) अनुसूचित जाति/अनुसूचित जनजाति/अन्य पिछड़ा वर्ग/अति पिछड़ा वर्ग की महिला अभ्यर्थियों को जो राजस्थान की स्थायी निवासी हैं, के मामले में 10 वर्ष की छूट दी जायेगी।
2. भूतपूर्व कैदी जो दण्डित होने से पूर्व राज्य सरकार के अधीन किसी पद पर मौलिक (Substantive) रूप से कार्य कर चुका हो और इन नियमों के तहत नियुक्ति के योग्य था, के मामले में अधिकतम आयु सीमा लागू नहीं होगी।
3. उस भूतपूर्व कैदी के मामले में जो अपनी दोषसिद्धि के पूर्व अधिकायु नहीं था और नियमों के अधीन नियुक्ति के पात्र था, उपरिदर्शित अधिकतम आयु सीमा में उसके द्वारा भुक्त कारावास की कालावधि के बराबर की अयधि की छूट दी जायेगी।
4. इस सेवा के किसी पद पर अस्थाई नियुक्त व्यक्ति अगर प्रारम्भिक नियुक्ति के समय आयु सीमा में थे, तो उन्हें आयु सीमा में समझा जावेगा चाहे वे विभाग के समक्ष आखिरी उपस्थिति के समय उसे पार कर चुके हो और यदि वे उनकी प्रारम्भिक नियुक्ति के समय इस प्रकार पात्र थे, तो उन्हें 2 अक्सर दिये जावेंगे।
5. रिलीज्ड इमरजेन्सी कमीशनड ऑफिसर/सोर्ट सर्विस कमीशनड सेवा में कमीशन ग्रहण करते समय यदि इस पद के लिए इस प्रकार पात्र थे, तो सेवा से रिहा होने के बाद विभाग के समक्ष उपस्थिति के समय चाहे वे आयु सीमा पार कर चुके हो, पात्र समझा जावेगा।
6. पूर्वी अफ्रीकी देश कीनिया, टांगानिका, युगान्डा और जंजीबार से संप्रत्यावर्तित व्यक्तियों के मामलों में कोई आयु सीमा नहीं होगी।
7. राजस्थान राज्य के क्रियाकलापों के संबंध में सेवारत कर्मचारी जो अधिष्ठायी (Substantive) हैसियत से कार्य कर रहे हैं की ऊपरी आयु सीमा 40 वर्ष होगी। यह छूट अर्जन्ट अस्थाई नियुक्त कर्मचारियों पर लागू नहीं होगी। पंचायत समितियों तथा जिला

- परिषदों और राज्य सरकार के पब्लिक सैक्टर उपक्रमों/निगमों के कार्यकलापों के संबंध में स्थाई रूप से सेवारत कर्मचारियों के लिये अधिकतम आयु सीमा 40 वर्ष होगी।
8. 1971 के भारत-पाक युद्ध के दौरान पाकिस्तान से विस्थापित व्यक्तियों के मामले में कोई आयु सीमा नहीं होगी।
 9. विधवाओं और विवाह-विच्छिन्न महिलाओं के मामले में कोई आयु सीमा नहीं होगी किन्तु राज्य सरकार द्वारा निश्चित की गई सेवानिवृत्ति आयु से उसकी आयु कम हो।
स्पष्टीकरण:- विधवा महिला के मामले में उसे किसी सक्षम प्राधिकारी का अपने पति की मृत्यु का प्रमाण-पत्र प्रस्तुत करना होगा तथा विवाह-विच्छिन्न महिला के मामले में विवाह विच्छेद का प्रमाण पत्र प्रस्तुत करना होगा।
 10. रिजर्विस्टों अर्थात् रिजर्व में स्थानान्तरित रक्षा कार्मिकों और भूतपूर्व सेना कार्मिकों के लिए अधिकतम आयु सीमा 50 वर्ष होगी। भूतपूर्व सेना कार्मिकों हेतु अधीनस्थ सेवा के आरक्षित पदों के संबंध में राजस्थान सिविल सेवा (भूतपूर्व सैनिकों का आगमन) नियम, 1988 के नियमानुसार उच्चतम आयु सीमा 50 वर्ष की आयु प्राप्त नहीं किया हुआ होना चाहिए परन्तु सैन्य क्रॉस/वीर चक्र या कोई अन्य उच्च विशेष योग्यता धारकों की दशा में उच्च आयु सीमा 2 वर्ष तक शिथिल करने योग्य होगी। भूतपूर्व सैनिकों के लिये आयु में रियायत के प्रावधान कार्मिक विभाग की अधिसूचना क्रमांक एफ.5(18) कार्मिक/क-2/84 पार्ट-II दिनांक 17.04.2018 के अनुसार भी लागू होंगे।
 11. कैडेट अनुदेशकों (Cadet Instructors) के मामले में उपरिपरिणित अधिकतम आयु सीमा को, उनके द्वारा, राष्ट्रीय कैडेट में की गयी सेवा के बराबर की कालावधि तक शिथिल किया जायेगा और यदि पारिणामिक आयु विहित अधिकतम आयु सीमा से तीन वर्ष से अधिक न हो तो ऐसे अभ्यर्थी को विहित आयु सीमा में समझा जायेगा।
 12. राजस्थान निःशक्त व्यक्तियों का (समान निःशक्तजन व्यक्तियों का समान अवसर अधिकारों का संरक्षण और पूर्णभागीदारी) नियोजन नियम 2011 के अनुसार विशेष योग्यजन को अधिकतम आयु सीमा में निम्नानुसार छूट देय होगी:-
 1. सामान्य वर्ग के विशेष योग्यजन हेतु 10 वर्ष
 2. पिछड़ा वर्ग/अति पिछड़ा वर्ग के विशेष योग्यजन हेतु 13 वर्ष
 3. ओजो/ओजोओ के विशेष योग्यजन हेतु 15 वर्ष

नोट:-

- (क) संस्थाई कर्मचारी को नियमानुसार अधिकतम आयु सीमा में छूट तभी दी जायेगी यदि वह बोर्ड कार्यालय में आवेदन प्राप्त करने की अन्तिम दिनांक तक संस्थाई कर्मचारी की श्रेणी में हो। आवेदक के अधिकायु का होने पर उसका आवेदन पत्र अस्वीकृत कर दिया जायेगा।
- (ख) आयु संबंधी छूट की अधिक जानकारी के लिये राजस्थान सचिवालय मंत्रालयिक सेवा नियम-1970 एवं राजस्थान लोक सेवा आयोग (लिपिकवर्गीय एवं अधीनस्थ) नियम तथा विनियम, 1999 एवं राजस्थान अधीनस्थ एवं मंत्रालयिक सेवा नियम-1999 यथा संशोधित एवं समय-समय पर राज्य सरकार द्वारा जारी संशोधन, निर्देश, परिपत्र एवं अधिसूचना का अध्ययन करें।
- (ग) उपरोक्त बिन्दु 9 की क.सं. 1 से 12 पर वर्णित आयु सीमा में छूट के प्रावधान "Non Cumulative" है अर्थात् अभ्यर्थियों को उपरोक्त क.सं. 1 से 12 में वर्णित किसी भी एक प्रावधान का अधिकतम आयु सीमा में छूट का लाभ दिया जायेगा। एक से अधिक प्रावधानों को जोड़ कर छूट का लाभ नहीं दिया जायेगा।

10. अंशदायी पेंशन:-

नये भर्ती/नियुक्त होने वाले कर्मचारियों के लिये नियमानुसार अंशदायी पेंशन योजना लागू होगी।

11. **विवाह पंजीयन :-** शासन के परिपत्र क्रमांक प.6(19) गृह-13/2006 दिनांक 22-5-2006 के अनुसार इस परिपत्र के जारी होने की दिनांक से राजकीय सेवा में नियुक्ति हेतु विवाह पंजीयन कराया जाना अनिवार्य किया गया है। तत्सम्बन्धी प्रमाण पत्र यथा समय वांछनीय होगा।

12. परीक्षा शुल्क जमा कराने एवं ऑनलाईन आवेदन पत्र भरने की अवधि-

- (क) परीक्षा शुल्क राज्य के निर्धारित ई-मित्र कियोस्क, जन सुविधा केन्द्र (C.S.C.), नेट बैंकिंग, ए.टी.एम. कम डेबिट कार्ड एवं क्रेडिट कार्ड के माध्यम से दिनांक 12.07.2018 से 10.08.2018 को मध्य रात्रि 12 बजे तक जमा कराया जा सकता है।
- (ख) ऑनलाईन आवेदन पत्र दिनांक 12.07.2018 से 10.08.2018 को मध्य रात्रि 12 बजे तक बोर्ड की वेबसाइट पर भरे जा सकते हैं (इसके उपरांत लिंक निष्क्रिय हो जायेगा)। आवेदकों को सलाह दी जाती है कि ऑनलाईन आवेदन की अन्तिम दिनांक का इन्तजार किए बिना समय सीमा के भीतर ऑनलाईन आवेदन करें।

13. **परीक्षा का माह एवं दिनांक :-** शीघ्रलिपिक पदों की भर्ती परीक्षा बोर्ड द्वारा संभवतया माह सितम्बर/अक्टूबर, 2018 में आयोजित परीक्षा केन्द्रों पर करवाई जायेगी। यह परीक्षा ऑनलाईन भी आयोजित करवाई जा सकती है। इस संबंध में विस्तृत सूचना बोर्ड की वेबसाइट एवं प्रेस विज्ञापित के माध्यम से अलग से दे दी जायेगी। बोर्ड के पास परीक्षा की दिनांक एवं स्थान में परिवर्तन करने का अधिकार सुरक्षित है।

