SHIVAJI UNIVERSITY, KOLHAPUR

ACCREDITED BY NAAC WITH 'A^{++}' GRADE

REVISED SYLLABUS FOR

BACHELOR OF SCIENCE

BOTANY PART- III
Semester V & VI

NEP 2020 (2.0) SYLLABUS TO BE IMPLEMENTED

FROM

JUNE, 2026 ONWARDS
(80:20Pattern)

SHIVAJI UNIVERSITY ,KOLHAPUR NEP-2020 (2.0): Credit Framework for UG(B. Sc.) Programme under Faculty of Science and Technology									
SEM (Level)	**COURSES**			OE	VSC/SEC	AEC/VEC/IKS	OJT/FP/CEP /CC/RP	TOTAL CREDITS	Degree/Cum. Cr. MEME
	Course-1	**Course-2**	**Course-3**						
SEMI (4.5)	DSC-I(2) DSC-II (2) DSC P-I(2)	DSC-I(2) DSC-II (2) DSC P-I(2)	DSC-I(2) DSC-II (2) DSC P-I(2)	OE-1(2) (T/P)		IKS-I(2)		22	UG Certificate 44
SEMII (4.5)	DSC-III(2) DSC-IV (2) DSC P-I(2)	DSC-III(2) DSC-IV (2) DSC P-I(2)	DSC-III(2) DSC-IV (2) DSC P-I(2)	OE-2(2) (T/P)		VEC-I(2) (Democracy, Election and Constitution)		22	
Credits	**8(T)+4(P)=12**	**8(T)+4(P)=12**	**8(T)+4(P)=12**	**2+2=4 (T/P)**		**2+2=4**		**44**	**ExitOption:4credits NSQF/Internship/Skill courses**
	Major		**Minor**						
SEMIII (5.0)	Major V(2) Major VI (2) Major P III (2)		Minor V(2) Minor VI (2) Minor P III(2)	OE-3(2) (T/P)	VSC I (2) (P) (Major specific) SEC I(2) (T/P)	AECI(2) (English)	CC-I(2)	22	UG Diploma 88
SEMIV (5.0)	Major VII(2) Major VIII (2) Major P IV (2)		Minor VII(2) Minor VIII (2) Minor P IV(2)	OE-4(2) (T/P)	SEC II(2) (T/P)	AECII(2) (English) VEC-II(2) (Environmental studies)	CEP-I (2)	22	
Credits	**8(T)+4(P)=12**		**8(T)+4(P)=12**	**2+2=4 (T/P)**				**44**	**ExitOption:4credits NSQF/Internship/Skill courses**
SEMV (5.5)	Major IX(2) Major X (2) Major P V A(2) Major P V B(2)	Major I (ELEC)(2) Major P-I (ELEC) (2)		OE-5(2) (T/P)	VSC II (2) (P) (Major specific)	AECIII(2) (English)	OJT(4)	22	UG Degree 132
SEMVI (5.5)	Major XI(2) Major XII (2) Major P VI A(2) Major P VI B(2)	Major II (ELEC)(2) Major P-II (ELEC) (2)			VSC III (2) (P) (Major specific) SEC III(2) (T/P)	AECIV(2) (English) IKS-II(2) (Major specific)	FP(2)	22	
Credits	8(T)+8(P)=16	4(T)+4(P)=8		2(T/P)	2(T/P)+4(P)=6	4+2=6	4+2=6	44	
Total Credits	**40+20=60**		**24**	**10**	**12**	**16**	**10**	**132**	**Exit option**
SEMVII (6.0)	Major –XIII(4) Major -XIV(4) Major(P),-VII(4) Major (P)-VIII(2)	Major III (4) (ELEC)	RM-I(4)					22	UG Honours Degree 176
SEMVIII (6.0)	Major –XV(4) Major -XVI(4) Major(P),-IX(4) Major (P)-X(2)	Major IV (4) (ELEC)					OJT(4)	22	
Credits	16(T)+12(P)=28	8(T)	4					44	
Total Credits	**68+28=96**		**28**	**10**	**12**	**16**		**176**	**Exit option**
SEMVII (6.0)	Major –XIII(4) Major -XIV(4) Major(P),-VII(2)	Major(4) (ELEC)	RM-I(4)				RP-(4)	22	UG Honours with research Degree 176
SEMVIII (6.0)	Major –XV(4) Major -XVI(4) Major(P),-VIII(2)	Major(4) (ELEC)					RP-(8)	22	
Credits	16(T)+4(P)=20	8(T)	4				12	44	
Total Credits	**60+28+88**		**28**	**10**	**12**	**16**	**22**	**176**	

Note:

University may decide to offer maximum of three subjects (Courses) in the first year. The student may select one subject out of combination of three subjects (Courses). (which a student has chosen in the first year) as a MAJOR subject (Course) and one subject (Course) as MINOR Subject in the second year. Thereby it is inferred that the remaining third subject (Course) shall stand discontinued.

DSC: Discipline Specific Core

Major: Manditory/Elective

Minor: Course may be from different discplines of same facultyof DSCMajor.

OE: (open elective): Elective courses/open elective to be choosen from facultyother than that of the Major.

VSC/SEC: Vocational skill courses(Mjor related)/Skill enhancement courses.

AEC/ VEC / IKS: Ability Enhancement Courses (English, Modern Indian Language) /Value Education Courses/ Indian Knowledge System (Generic & Specific))

A] Ordinance and Regulations: (As applicable to Degree Course)

B] Shivaji University, Kolhapur

Revised Syllabus for Bachelor of Science

1. TITLE: Subject- Botany

Optional under the Faculty of Science and Technology

2. YEAR OF IMPLEMENTATION: Revised Syllabi will be implemented from June 2026 onwards.

3. PREAMBLE:

[**Note:** The Board of Studies should briefly mention foundation, core and applied components of the course/paper. The student should get into the prime objectives and expected level of study with required outcome in terms of basic and advance knowledge at examination level.]

4. GENERAL OBJECTIVES OF THE COURSE:

(As applicable to the Degree concerned) Objectives:

1. To impart knowledge of science is the basic objective of education.
2. To develop scientific attitude is the major objective to make the students open minded, critical, curious.
3. To develop skill in practical work, experiments and laboratory materials and equipment along with the collection and interpretation of scientific data to contribute the science.
4. To understand scientific terms, concepts, facts, phenomenon and their relationships.
5. To make the students aware of natural resources and environment.
6. To provide practical experience to the students as a part of the course to develop scientific ability to work in the field of research and other fields of their own interest and to make them fit for society.
7. To The students are expected to acquire knowledge of plant and related subjects so as to understand natural phenomenon, manipulation of nature and environment in the benefit of human being.
8. To develop ability for the application of the acquired knowledge to improve agriculture and other related fields to make the country self-reliant and sufficient.
9. To create the interest of the society in the subject and scientific hobbies, exhibitions and other similar activities.

5. DURATION:

The course shall be a full-time course.

6. PATTERN:

Pattern of Examination will be Semester.

7. FEE STRUCTURE:

As per Government / University rules.

1. Refer brochure and prospectus of concern affiliated college/institute to Shivaji University, Kolhapur.
2. Other fee will be applicable as per rules and norms of Shivaji University, Kolhapur.

8. ELIGIBILITY FOR ADMISSION:

As per guidelines obtained from Shivaji University, Kolhapur by following rules and regarding reservations by Govt. of Maharashtra.

9. MEDIUM OF INSTRUCTION:

As per guidelines guide lines given by Govt. of Maharashtra and Shivaji University, Kolhapur

10. STRUCTURE OF COURSE- B. Sc. III Botany (Optional)

THIRD YEAR (SEMESTER V/VI) (NO. OF PAPERS , PRACTICALS OJT& FP)

Sr. No.	Subjects/Papers	Theory	Internal	Practical	Total Marks
	SEMESTER V				
1	**(Major)Paper-IX**	40	10	50	**100**
2	**(Major) Paper- X**	40	10	50	**100**
3	**Major (Elective) Paper -I**	40	10	50	**100**
4	**VSC II(P) (Major specific)**				**50**
5	**OE(T/P)**	40	10	50	**50**
6	**OJT**				**100**
	SEMESTER VI				
7	**(Major)Paper-XI**	40	10	50	**100**
8	**(Major)Paper-XII**	40	10	50	**100**
9	**Major (Elective) Paper -II**	40	10	50	**100**
10	**VSC III(P) (Major specific)**	-		50	**50**
11	**SEC III(T/P)**	40	10	50	**50**
12	**IKS II (Major specific)**	40	10	-	**50**
12	**FP**				**50**
				Total	**1000**

11. STRUCTURE OF B. SC. III - SEMESTER V AND VI

SEMESTER V								
TEACHING SCHEME								
		THEORY			PRACTICAL			
Sr. No.	Subject Title	Credits	No. of periods	Hours	Credits	No. of periods	Hours	Total
SEMESTER V								
1	**(Major)Paper-IX**	2	**2**	2	2	**4**	4	6
2	**(Major) Paper- X**	2	**2**	2	2	**4**	4	6
3	**Major (Elective) Paper -I**	2	**2**	2	2	**4**	4	6
4	**VSC II(P)(Major specific)**	2			2	**4**	4	4
5	**OE(T/P)**	2	2(T),**4(P)**	2	2	**4**	4	4
6	**OJT**				4	8	8	8
Total		**8**	**8+2**	**8**	**14**	**28**	**28**	**34+/- 2**
SEMESTER VI								
7	**(Major)Paper-XI**	2	**2**	2	2	**4**	4	6
8	**(Major)Paper-XII**	2	**2**	2	2	**4**	4	6
9	**Major (Elective) Paper -II**	2	**2**	2	2	**4**	4	6
10	**VSC III(P) (Major specific)**				2	**4**	4	4
11	**SEC III(T/P)**	2	**2**(T),**4(P)**	2	2	**4**	4	4
12	**IKS II(Major specific)**	2	**2**					2
13	**FP**				2	**4**	4	4
	TOTAL	**10**	**10+2**	**8**	**12**	**24**	**24**	**34+/- 2**
GRANT TOTAL		**18**	**18+2+2**	**16**	**26**	**52**	**52**	**64+/-4**

12. SCHEME OF EXAMINATION:

- The theory and practical examination shall be conducted at the end of each semester.
- Each theory paper shall carry 50 marks.
- The evaluation of the performance of the students in theory papers shall be based on Semester Examination of 40 (University Examination) + 10 (Internal examination) marks.
- Question Paper will be set in the view of the /in accordance with the entire Syllabus and preferably covering each unit of syllabi.

13. STANDARD OF PASSING:

As prescribed under rules & regulation for each degree.

. Standard of passing and decleration of CGPA/SGPA, Grading and declaration of results:

Shivaji University has adopted 10 point Grading System as follows:

a) In each semester, marks obtained in each course (Paper/ Practical) are converted to grade points:

i) If the total marks of the course are 100 and passing criteria is 40%, then use the following Table 1 for the conversion.

ii) If total marks of any of the course are 50 and passing criterion is 40%, then marks obtained are converted to marks out of 100 as below and then grade points are computed using Marks out of 100 as per Table 1.

$$Marks\ out\ of\ 100 = \frac{Marks\ obtained\ by\ student\ in\ that\ course}{Total\ marks\ of\ that\ course} \times 100$$

Table 1: Conversion of Marks out of 100 to grade point

Sr. No.	Marks Range out of 100	Grade point	Letter grade
1	80 – 100	10	O: Outstanding
2	70 – 79	9	A+: Excellent
3	60 – 69	8	A: Very Good
4	55 – 59	7	B+: Good
5	50 – 54	6	B: Above Average
6	45 – 49	5	C: Average
7	40 – 44	4	P: Pass
8	0 – 39	0	F: Fail
9	Absent	0	Ab: Absent

Table 2: Conversion of Marks out of 50 to grade point

Sr. No.	Marks Range out of 50	Grade point	Letter grade
1	40 – 50	10	O: Outstanding
2	35 – 39	9	A+: Excellent
3	30 – 34	8	A: Very Good
4	28 – 29	7	B+: Good
5	25 – 27	6	B: Above Average
6	23 – 24	5	C: Average
7	20 – 22	4	P: Pass
8	0 – 19	0	F: Fail
9	Absent	0	Ab: Absent

b) Computation of Semester Grade Point Average (SGPA):

Based on the grade points earned in each course in each semester, *Semester Grade Point Average (SGPA)* is computed as follows:

The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student in that semester and the sum of the number of credits of all the courses undergone by a student in that semester. The SGPA of the i^{th} semester is denoted by S_i. The formula is given by

$$SGPA of semester i = S_i = \frac{\sum_{j=1}^{k} c_j \times G_j}{\sum_{j=1}^{k} c_j}$$

c) Computation of Semester Grade Point Average (SGPA) :

Based on the SGPA of each semester, Cumulative Grade Point Average (CGPA) is computed as follows:

The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programmed,

$$CGPA = \frac{\sum_{i=1}^{m} C_i \times S_i}{\sum_{i=1}^{m} C_i}$$

where c_j is the number of credit of j^{th} course , G_j is the grade points earned in the j^{th} course and k be the number of courses in i^{th} semester.

Where C_i is the total number of credits in i^{th}semester, S_i is the SGPA of i^{th}semester and m is the number of semesters in the programme.

d)Based on CGPA, final letter grade is assigned as below:

Table 3: Final Cumulative Grade Point Average (CGPA) and Final Grade for course

Sr. No.	CGPA Range	Grade	Grade Descriptions
1	9.50 – 10.00	O	Outstanding
2	8.86 – 9.49	A+	Excellent
3	7.86 – 8.85	A	Very Good
4	6.86 – 7.85	B+	Good
5	5.86 – 6.85	B	Above Average
6	4.86 – 5.85	C	Average
7	4.00 – 4.85	P	Pass
8	0.00 – 3.99	F	Fail
9	Nil	AB	Absent

Remarks:

1. B+ is equivalent to 55% marks and B is equivalent to 50 % marks. The final later grade is based on the grade points in each course of entire programme and not on marks obtained each course of entire programme.
2. The SGPA and CGPA shall be round off to two decimal points.

14. NATURE OF QUESTION PAPER AND SCHEME OF MARKING:

(Unit wise weightage of marks should also be mentioned)

Q.1 Multiple choices questions (8-questions) --- 08 Marks

Q.2 Attempt **any two** of the following.

(Essay type/Broad answer questions) ---- 16 Marks

Q.3 Write short notes (**any four**) --- 16 Marks

15.EQUIVANLENCE IN ACCORDANCE WITH TITLES AND CONTENTS OF PAPERS-

Due to NEP2.00 makes it impossible to provide equivalence

(FOR REVISED SYLLABUS)

(Introduced from June 2026 onwards)

Old Syllabus (Semester pattern)		**Revised Syllabus (Semester pattern)**		
Paper No.	**Title of Old Paper**	**Sem. No.**	**Paper No.**	**Title of New Paper**
IX	Reproductive Biology of Angiosperms	**V**	**Major IX**	Reproductive Biology of Angiosperms
XI	Plant Biotechnology		**Major X**	Plant Biotechnology and Bioinformatics
XIII	Plant Biochemistry and Research Methodology		**Major Elective I**	Plant Biochemistry
			Major Elective I	Fungal Diversity And Its Industrial Applications
			Major Elective I	Herbarium Techniques
			Major Elective I	Industrial Botany And Applied Plant Sciences
XII	Horticulture		**VSC II (Major specific)**	Horticulture
			OE II	Mushroom Cultivation and Marketing
			OJT	On Job Training
		VI	**Major XI**	Plant Breeding and plant genetic resources management
			Major XII	Plant Diversity and Paleobotany
X	Plant Metabolism and Stress Biology		**Major Elective II**	Plant Metabolism and Stress Physiology
			Major Elective II	Epidemiology and Control of Emerging Crop Diseases
			Major Elective II	Measures And Sustainable uses of Plant Diversity
			Major Elective II	Industrial Phytotechnology And Agro-Botany
XIV	Natural Resource Management and Herbal Technology		**VSC III (Major specific)**	Herbal Technology
XVI	Plant Breeding, Bioinformatics and Biostatistics		**SEC III**	Biostatistics
XV	Plant Diversity and Ethnobotany		**IKS II(Major specific)**	Ethnobotany
			FP	Field Project

B.SC.-III BOTANY

SEMESTER -V

MAJOR IX: REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Credits: 2; 2 Hours per week **Total : 30 Hours Marks: 40+10**

Course Objectives

To introduce students to the fundamental concepts of reproductive biology of angiosperms.
To understand structure, development, and functioning of reproductive organs.
To correlate theoretical knowledge with laboratory-based practical observations.

Course Outcomes: After completion of the course, students will be able to

Explain the reproductive structures and processes in angiosperms.
Describe anther, pollen, ovule, pollination, and fertilization mechanisms.
Apply basic reproductive biology concepts through practical demonstrations.

Module No.	Module	Sub-Module	Periods
1.	**Organization of a flower Pollination and Fertilization**	**1.1 Concept of flower as a modified shoot** (Stem nature of thalamus and leaf nature of floral parts). **1.2 Structure and functions of a typical stamen**; structure of a tetrasporangiate anther and pollen grain. **1.3 Structure and functions of a typical carpel**. Structure of a typical ovule and its types.	**08**
		1.4 Pollination: Definition and Types (**Anemolphily**-*Zea* mays; Hydrophily-Vallisneria spiralis; Entemophily-*Calotropis gigantea*). **1.5 Microsporogenesis**; pollen germination and development of male gametophyte. **1.6 Megasporogenesis**; development of embryo sac: Monosporic, Bisporic and Tetrasporic. **1.7 Fertilization**: Definition and Importance. Entry of pollen tube (Porogamy, Chalazogamy and Mesogamy). Double fertilization and triple fusion and its significance.	**07**
2.	**Embryo and Endosperm Development**	**2.1Development of and types of endosperms** (Nuclear, Helobial and Cellular). **2.2 Development and structure of dicot and monocot embryo in angiosperms.**	**08**

		2.3Polyembryony: Introduction and causes of polyembryony**.** Types of polyembryony (True polyembryony-Clevage and Adventative; False polyembryony.) Significance of polyembryon**y.** **2.4 Apomixis:** Introduction and causes. Types (Gametophytic and sporophytic). Significance of apomixis	**07**

B.SC.-III BOTANY

SEMESTER -V PRACTICALS BASED ON MAJOR IX ,VA

REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Course Objectives

To identify the structural organization of a typical angiosperm flower.

To understand the function of epidermis, endothecium, middle layers, and tapetum

To analyze structural variations in pollen exine and aperture patterns.

To determine optimal sucrose concentration required for pollen tube growth.

To isolate intact embryos from young developing dicot seeds.

Course Outcomes

Students can classify floral organs based on reproductive functionality

Students identify the four distinct layers of the anther wall

Students utilize palynological terminology to describe diverse pollen shapes

Students prepare viable nutritive mediums for in-vitro pollen germination

Students successfully extract intact dicot embryos without inflicting tissue damage.

PRACTICAL SYLLABUS (15 Practical's)

1. Study of flower as a reproductive unit: Thalamus, Accessary and Necessary whorls (Any suitable material).
2. Study of T. S. of tetrasporangiate anther (Any suitable material).
3. Study of pollen morphology and pollen viability with any suitable method.
4. Study of pollen germination by hanging drop method.
5. Study of ovule types through permanent slides/Charts/Photos.
6. Study of embryo sac types through permanent slides/Charts/Photos.
7. Dissection of dicot embryo from any suitable material.
8. Study of structure of floral parts (pollinia) and pollination mechanism in *Calotropis*.
9. Study of structure of dicot embryo with the help of Photograph/Model/Staining method.
10. Study of structure of monocot embryo with the help of Photograph/Model/Staining method.
11. Study of diversity in the structure of stigma and stigmatic papillae.
12. Study of anatomical diversity in the morphology of style.
13. Study of structure of endosperm with the help of Photograph/Model/Staining method.
14. Study of structure of floral parts and pollination mechanism in Maize.
15. Botanical Excursion to familiarize students with different plants. (Report should be written in Journal).

List of Recommended books.

1. Bhojwani, S.S. & Bhatnagar, S.P. (2000). *The Embryology of Angiosperms*. Vikas Publishing House, New Delhi.
2. Johri, B.M. (1984). *Embryology of Angiosperms*. Springer, Verlang Berlin.
3. Maheshwari, P. (1950). *An Introduction to the Embryology of Angiosperms*. McGraw-Hill.
4. Naik, V.N. (1984). Taxonomy of Angiosperms. Tata McGraw Hills, New York,
5. Raghavan, V. (1986). Embryogenesis in Angiosperms: A development and experimental study. Cambridge University Press, USA.

B.SC.-III BOTANY

SEMESTER –V

MAJOR PAPER X: PLANT BIOTECHNOLOGY & BIOINFORMATICS

Credits: 2; 2 Hours per week **Total : 30 Hours Marks: 40+10**

Learning Objectives

To introduce fundamental concepts, history, and scope of plant biotechnology and tissue culture.
To explain principles, tools, and applications of genetic engineering and genome editing in plants.
To familiarize students with biological databases and bioinformatics resources relevant to plant sciences.
To develop conceptual understanding of sequence analysis, molecular phylogeny, and their applications.
To enhance analytical thinking and ethical awareness related to biotechnological applications.

Learning Outcomes

After successful completion of the course, students will be able to:
Explain principles and applications of plant tissue culture.
Describe tools, methods, and applications of genetic engineering.
Identify and classify biological databases and sequence analysis used in plant sciences.
Explain molecular phylogeny and its applications in plant evolution.
Evaluate ethical, environmental, and socio-economic aspects of biotechnology.

Module	Unit	Topic: Subtopics	Periods
Module 1 **Plant Biotechnology**	**Unit 1a: Foundations and Techniques of Plant Biotechnology**	1.1 Introduction to Plant Biotechnology: Introduction and applications	7
		1.2 Principles of Plant Tissue Culture: Totipotency and Plasticity; Laboratory Equipment: Autoclave and Laminar Air Flow; Sterilization techniques: Wet and Dry	
		1.3 Culture Media & Plant Growth Regulators: Media Composition (MS), Role of auxins and cytokinin	
		1.4 Organogenesis and Callus Culture: Dedifferentiation and redifferentiation; Callus culture: Technique and applications	
		1.5 Protoplast Technology & Synthetic Seeds: Protoplast isolation; culture; production of cybrids; synthetic seed production	
		1.6 Micropropagation: Technique and applications	
	Unit 1.b Genetic Engineering – Principles, Tools, and Applications	1.7 Genetic Engineering: Introduction and applications in Agriculture and medicine field.	8
		1.8 Enzymes in Genetic Engineering: Restriction endonucleases, ligases, polymerases, kinases	
		1.9 Gene Cloning Vectors and Gene libraries: Prokaryotic vectors (pBR322); Eukaryotic vectors (YAC); Construction of genomic and cDNA libraries	
		1.10 Methods of Transgenic Plant Production: Agrobacterium-mediated	

		transformation; electroporation; microinjection	
		1.11 Screening techniques for transgenics and PCR: Selectable markers; reporter genes (GUS, GFP, Luciferase); PCR Technique	
Module 2: Bioinformatics	**Unit 2a. Bioinformatics: Databases and Resources**	2.1 Bioinformatics: Introduction and Applications in Plant taxonomy, molecular systematics, crop improvement and biodiversity conservation	8
		2.2 Biological Data: DNA, RNA and protein sequences.	
		2.3 Biological Databases: Introduction, Classification of databases (primary, secondary and specialized databases) Examples of databases: Information and role of NCBI, EMBL and PIR	
		2.4 Similarity and Alignment: Sequence Homology; Pairwise and multiple sequence alignment	
	Unit 2b. Bioinformatics: Sequence Analysis, and Molecular Phylogeny	2.5 BLAST (Basic Local Alignment Search Tool): Introduction, types and biological significance	7
		2.6 Molecular Phylogeny and Phylogenetic Trees: Concept of molecular phylogeny; molecular markers, Phylogenetic Trees and types of phylogenetic trees.	

B.Sc.-III BOTANY

SEMESTER –V

MAJOR PRACTICAL BASED ON MAJOR PAPER X: VB

PLANT BIOTECHNOLOGY & BIOINFORMATICS

Credits: 2; 4 Hours per week **Total : 60 Hours: Marks: 50**

Learning Objectives:

1. To introduce laboratory layout, safety measures, and aseptic techniques used in plant tissue culture.
2. To train students in advanced *in vitro* techniques such as micropropagation, protoplast isolation, and synthetic seed preparation.
3. To develop basic molecular biology skills including plant DNA extraction and quantification.
4. To familiarize students with biological databases and sequence file formats used in plant sciences.
5. To develop bioinformatics skills in sequence retrieval, alignment, BLAST analysis, and evolutionary interpretation.

List of Experiments/Practical's

1.To study the layout of plant tissue culture laboratory

2&3.To prepare and sterilize Murashige and Skoog (MS) culture medium.

4.To demonstrate the technique of Micropropagation

5.To demonstrate the technique of Callus culture

6.To isolate viable protoplasts from plant cells

7.To prepare synthetic seeds by encapsulating somatic embryos

8.To isolate genomic DNA from plant material.

9.To estimate plant genomic DNA by DPA method.

10.To search and download plant gene sequence from NCBI.

11.To retrieve protein sequences from public biological databases.

12.To perform BLAST analysis of a plant gene sequence.

13.To translate DNA sequence in to protein using online tools.

14.To construct a simple phylogenetic tree using 3-5 sequences.

15.Submission of PPT on any topic of plant biotechnology and Bioinformatics

Learning Outcome

After completing this laboratory course, students will be able to:

1. Practice aseptic techniques and follow standard procedures in a plant tissue culture laboratory.
2. Prepare, sterilize, and use MS culture media for plant tissue culture and callus induction.
3. Perform micropropagation, protoplast isolation, and synthetic seed preparation using i*n vitro* techniques.
4. Extract, quantify, and analyze plant genomic DNA.
5. Retrieve and interpret plant gene sequence data from biological databases in FASTA format.
6. Analyze sequence similarity using alignment tools and BLAST to infer evolutionary relationships.

Suggested Reading / References

1. Bhojwani SS, Razdan MK. *Plant tissue culture: theory and practice*. Amsterdam: Elsevier Science; 1996.
2. George EF, Hall MA, De Klerk GJ. *Plant propagation by tissue culture*. Dordrecht: Springer; 2008.
3. Trigiano RN, Gray DJ, editors. *Plant tissue culture, development, and biotechnology*. Boca Raton: CRC Press; 2011.
4. Glick BR, Pasternak JJ, Patten CL. *Molecular biotechnology: principles and applications of recombinant DNA*. 4th ed. Washington (DC): ASM Press; 2010.
5. Brown TA. *Gene cloning and DNA analysis: an introduction*. 7th ed. Oxford: Wiley-Blackwell; 2016.
6. Slater A, Scott NW, Fowler MR. *Plant biotechnology: the genetic manipulation of plants*. 2nd ed. Oxford: Oxford University Press; 2008.
7. Primrose SB, Twyman RM. *Principles of gene manipulation and genomics*. 7th ed. Oxford: Wiley-Blackwell; 2006.
8. Mount DW. *Bioinformatics: sequence and genome analysis*. 2nd ed. Cold Spring Harbor (NY): Cold Spring Harbor Laboratory Press; 2004.
9. Xiong J. *Essential bioinformatics*. Cambridge: Cambridge University Press; 2006.
10. Lesk AM. *Introduction to bioinformatics*. 4th ed. Oxford: Oxford University Press; 2019.
11. Higgs PG, Attwood TK. *Bioinformatics and molecular evolution*. Oxford: Blackwell Publishing; 2005.
12. Hall BG. *Phylogenetic trees made easy: a how-to manual*. 5th ed. Sunderland (MA): Sinauer Associates; 2018.

Online Databases and Learning Resources (for practical exposure)

1. National Center for Biotechnology Information (NCBI): GenBank, BLAST, and ENTREZ system – https://www.ncbi.nlm.nih.gov
2. European Molecular Biology Laboratory – European Bioinformatics Institute (EMBL-EBI) – https://www.ebi.ac.uk
3. DNA Data Bank of Japan (DDBJ) – https://www.ddbj.nig.ac.jp
4. UniProt Protein Knowledgebase – https://www.uniprot.org
5. The Arabidopsis Information Resource (TAIR) – https://www.arabidopsis.org

Supplementary Learning Resources

1. NPTEL Online Courses on Plant Biotechnology and Bioinformatics – https://nptel.ac.in
2. FAO Biotechnology Resources – https://www.fao.org/biotechnology

B.SC.-III BOTANY SEMESTER –V

MAJOR ELECTIVE I: PLANT BIOCHEMISTRY

Credits: 2; 2 Hours per week **Total : 30 Hours Marks: 40+10**

Course Objectives

To provide students with a fundamental understanding of biomolecules, including their structure, classification, properties, and biological significance.

To develop knowledge about pH, buffers, and acid–base balance and their importance in maintaining physiological conditions in living systems.

To introduce the concepts of enzyme structure, mechanism of action, enzyme kinetics, and enzyme inhibition in relation to biological functions.

To explain covalent and non-covalent interactions, bioenergetics, and thermodynamic principles governing energy transformations and metabolic processes in biological systems.

Course Outcomes

After successful completion of the course, students will be able to:

Explain the structure, classification, and physicochemical properties of biomolecules present in living systems.

Describe the principles of pH and buffer systems and evaluate their role in maintaining acid–base balance in biological and physiological conditions.

Illustrate the structure, mechanism of action, and biological significance of enzymes, including enzyme kinetics and inhibition.

Apply the concepts of biomolecular interactions, bioenergetics, and thermodynamics, and demonstrate basic analytical techniques related to biomolecules and enzymes using standard experimental protocols.

Module No.	Module	Sub-module	Periods Allotted
1.	**Fundamentals of Biochemistry and Analytical techniques**		15
	1a. Introduction to Biochemistry	1.1 Scope and importance of biochemistry in plants. 1.2 Covalent and non-covalent interactions, Van der Waal's forces, electrostatic and hydrophobic interactions. 1.3 pH and Buffers (inorganic and organic), significance an 1.4 Isoelectric point. 1.5Laws of thermodynamics (first and second law), 1.6 Redox potential in plant metabolism	07
	1b. Analytical Techniques	1.7 Spectrophotometry: Principle and applications 1.8 Chromatography: Paper chromatography, Thin layer chromatography, GLC, HPLC (Principle and application) 1.9 Electrophoretic technique (SDS-PAGE) 2.0 Microscopy techniques: Light and Electron Microscopy (Principle, Construction and Working)	08

2	**Biomolecules and Enzymology**		15
	2a. Biomolecules	2.1 **Lipids**: Classification of lipids, Outline of fatty acid biosynthesis, glyoxylate cycle, gluconeogenesis and its role in mobilization of the lipids during seed germinations 2.2 **Amino acids and Proteins**: Structure and classification of amino acids; primary, secondary, tertiary and quaternary structure of proteins; Denaturation and renaturation of proteins	09
	2b **Enzymology**	2.3 General structure, Nomenclature and Classification of enzymes Co-factors, co-enzymes and isozymes. 2.4 Mechanism of enzyme action (Lock and Key model and Induced fit hypothesis) 2.5Factors affecting enzyme activity	06

B.SC.-III BOTANY SEMESTER –V

PRACTICALS BASED ON MAJOR ELECTIVE I: PLANT BIOCHEMISTRY

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Course Objectives

To explain the theoretical principles of molarity, normality, and percentage mass/volume concentrations.

To describe the Henderson-Hasselbalch equation governing weak acid and conjugate base dynamics.

Students calculate exact salt-to-acid ratios required to reach target biochemical pH targets.

To differentiate between the optical pathways and working principles of TEM and SEM systems.

Course Outcomes

Students calculate necessary solute masses and stock volumes for diverse concentration metrics.

Students calibrate and operate digital pH electrodes without contaminating standard reference materials.

Students evaluate 3D surface topography and cellular architectural features using SEM micrographs.

Practicals:

1. Preparation of solutions (molar, normal and percentage solutions).
2. Preparation of standard buffers (citrate and phosphate) and determination of pH of a solution.
3. Study of Electron Microscopic Techniques (TEM and SEM) Using Micrographs
4. Estimation of proteins by Biuret method.
5. Estimation of chlorophyll using colorimeter.
6. Demonstration of principle and working of spectrophotometer.
7. Demonstration of principle and working of electrophoresis technique
8. To separate amino acids by thin layer chromatography (TLC).
9. To separate chloroplast pigments by paper chromatography.
10. Colorimetric estimation of proteins using Folin–Ciocalteu (Lowry's) method.
11. Effect of temperature on the activity of enzyme amylase/catalase.
12. Effect of pH on the activity of enzyme dehydrogenase.
13. Study of activity of lipases in germinating seeds.
14. Qualitative tests for proteins and amino acids.
15. Qualitative tests for lipids.

Suggested Readings (or Books Recommended):

1. Lehninger, A. L., Nelson, D. L., & Cox, M. M. *Lehninger Principles of Biochemistry*. W.H. Freeman & Company.
2. Stryer, L. *Biochemistry*. W.H. Freeman & Company.
3. Satyanarayana, U., & Chakrapani, U. *Biochemistry*. Elsevier.
4. Ganai, B. A. *Experimental Biochemistry*. PHI Learning.
5. Rizvi, E. H. *Bioanalytical Chemistry*. Springer.
6. Palmer, T., & Bonner, P. L. *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry*. Woodhead Publishing, 2017.
7. Punekar, N. S. *Enzymes: Catalysis, Kinetics and Mechanisms*. Springer.
8. Dixon, M., & Webb, E. C. *Enzymes*. Academic Press.
9. Segel, I. H. *Biochemical Calculations*. John Wiley & Sons, New York.
10. Haynie, D. T. *Biological Thermodynamics*. Cambridge University Press.
11. Dey, N. C. *Thermodynamics: Principles and Applications*. Tata McGraw-Hill.
12. Voet, D., Voet, J. G., & Pratt, C. W. *Fundamentals of Biochemistry: Life at the Molecular Level*. John Wiley & Sons.

B.SC.-III BOTANY

SEMESTER –V

MAJOR ELECTIVE I: FUNGAL DIVERSITY AND ITS INDUSTRIAL APPLICATIONS

Credits: 2; 2 Hours per week **Total : 30 Hours Marks: 40+10**

Course Objectives

To introduce students to the fundamental concepts of fungal diversity.

To understand industrial applications of Fungi

To correlate theoretical knowledge with laboratory-based practical observations.

Course Outcomes: After completion of the course, students will be able to

Have a comprehensive knowledge of different groups of fungi as per their habit, habitat, morphology, reproduction, distribution, etc.

Understand that Fungal biotechnology is used in the processing, production, and preservation of commercial byproducts.

Gain experiential knowledge of the identification of fungi and processes.

THEORY SYLLABUS (30 lectures)

Module No.	Module	Sub-Module	Lectures
1.	Diversity of fungi	1.1: General definition and characteristics of Fungi; Key characteristics of the following Fungal phyla (Hawksworth, et. al., 1995)- a. Phylum Ascomycota b. Phylum Basidiomycota→ i) Class Basidiomycetes ii) Class Teliomycetes iii) Class Ustomycetes c. Phylum Chytridiomycota→ Class Chytridiomycetes d. Phylum Zygomycota→ i) Class Trichomycetes ii) Class Zygomycetes 1.2: Diversity of fungi according to number, nutrition, habitat and morphology- unicellular, multicellular, dimorphic, Holomorph, Anamorphs, Teleomorphs (one example each) 1.3: Asexual reproduction in fungi- fragmentation, fission, budding, and spores (conidia, zoospores, or sporangiospores- one example each) 1.4: Sexual reproduction in fungi- Plasmogamy, Karyogamy and meiosis, diversity in Ascocarps [Apothecium e.g. *Ascobolus*, Perithecium e.g. *Xylaria*, Cleistothecium e.g. *Uncinula*, Pseudothecium e.g *Ascochyta*] and Basidiocarps [Agarics e.g. *Agaricus* or any suitable mushroom, Polypores (Bracket/Shelf Fungi): e.g. *Ganoderma*; Gasteroid (Puffballs and Earthstars) e.g *Lycoperdon*, *Geastrum*; Clavarioid (Club and Coral Fungi) e.g. *Ramaria*; Jelly fungi e.g. *Tremella*] 1.5: Specialized existence of fungi in nature- Mycorrhiza (Arbuscular Mycorrhizae), Lichens, Endophytes, Fungi-insect associations (Ambrosia Beetles)	15
2	**Industrial Applicatio**	2.1: Mushroom cultivation- Process of cultivation of *Agaricus bisporus,*	15

	ns of Fungi	*Pleurotus sajor-kaju, Ganoderma lucidum* 2.2: Yeast fermentation (*Saccharomyces cerevisiae*) for baking bread, brewing beer, and winemaking. 2.3: Penicillin production by submerged fermentation technique using *Penicillium chrysogenum*. 2.4: Mycorrhizal inoculant production process 2.5: Biopesticides from fungi/ Mycopesticides production by cultivating entomopathogenic fungi (*Beauveria bassiana*, and *Metarhizium*) to create, harvest, and formulate spores.	

B.SC.-III BOTANY

SEMESTER –V

PRACTICALS BASED ON MAJOR ELECTIVE I: FUNGAL DIVERSITY AND ITS INDUSTRIAL APPLICATIONS

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

1-2. To study the cultivation technique of *Pleurotus sajor-kaju*.

3. To study the seed treatment method using *Trichoderma harzianum/viride.*

4. To study the process of fermentation by Yeast.

5-6. Arbuscular Mycorrhizal Fungi (AMF) culture production via trap culture method utilizing host plants (e.g., Sorghum, Maize).

7. Study of *Cordyceps militaris*- collection from natural habitat, cultivation, and products available in markets from India.

8-9. To study isolation, inoculation, culture and identification of soil fungi.

10. To study fungi involved in the process of cheese making in industry (Camembert cheese).

11-12. To study fungal growth & biomass determination (Dry Weight).

13. Study of different methods of sterilization used in fungal studies.

14. To study various media for cultivation of fungi- Liquid media- Czapek Dox Liquid Medium; Broth medium- Sabouraud Dextrose Broth, semi-solid medium- Potato Dextrose Agar.

15. Excursion to familiarize students with fungal diversity/ Project work- Fungi associated with vegetables and fruits during transport and storage.

References Books:

1. **Introductory Mycology**, 4th Edition, Constantine J. Alexopoulos, Charles W. Mims, Meredith M. Blackwell, ISBN: 978-0-471-52229-4, January 1996, 880 pages

2. **21st Century Guidebook to Fungi,** David Moore**,** Geoffrey D. Robson**,** Anthony P. J. Trinci, January 2000**,** DOI: 10.1017/CBO9780511977022**,** ISBN: 978110741971.

3. **The Fungi: An Advanced Treatise, Volumes 1-5**, Geoffrey Clough Ainsworth, Alfred S. Sussman, Frederick Kroeber Sparrow, Academic Press, 1965, ISBN 012045601X, 97801204560.

4. **Introduction to Fungi 3rd Edition**, 2007, by John Webster & R.S.S. Webster, Cambridge University Press, ISBN print-13 978-0-511-27783-2, eBook ISBN-13 978-0-511-27783-2.

5. **Fungi: Experimental Methods In Biology** by Ramesh Maheshwari, 2011, CRC Press, 358 pages

6. **Advances in Fungal Biotechnology** by Mahendra Rai, 2013, ISBN-10 9788189866532, ISBN-13 978-8189866532, I K International Publishing House Pvt. Ltd.

7. **Fungal Biotechnology: Prospects and Avenues** edited by Sunil K. Deshmukh, K. R. Sridhar, S. M. Badalyan, ISBN 9781032163864, 450 Pages, 2024 by CRC Press.

8. **Fungi and Fungal Products in Human Welfare and Biotechnology** edited by Sunil Kumar Deshmukh, 2023, Springer,

9. **Research Advances in the Fungal World** edited by Pankaj Kumar Chaurasia & Shashi Lata Bharati, 2020, ISBN: 978-1-53617-197-6, Nova Science Publishers, Inc. USA.

10. **Fungal Biotechnology-Industrial Applications and Market Potential**, 2024, Academic Press, Editors: Ram Sarup Singh, Ranjeeta Bhari, Paperback ISBN: 9780443132636, eBook ISBN: 9780443132643.

B.SC.-III BOTANY

SEMESTER –V

MAJOR ELECTIVE I : HERBARIUM TECHNIQUES

Credits: 2; 2 Hours per week **Total : 30 Hours Marks: 40+10**

Course Objectives

To introduce students to the principles and importance of herbarium techniques.

To develop skills in plant collection, preservation, identification, and documentation.

To train students in herbarium preparation, maintenance, and digitization.

To understand modern methods and applications of herbaria in taxonomy, biodiversity, and conservation.

Course Outcomes

After completion of the course, students will be able to:

Understand the role and significance of herbaria in botanical sciences.

Collect, process, preserve, and mount plant specimens scientifically.

Prepare herbarium labels and maintain herbarium records.

Identify plant specimens using floras, manuals, and keys.

Understand herbarium management and digitization techniques.

Module	Submodule	Topic	Hours
1. Fundamentals Of Herbarium Techniques	**1a. Introduction and Collection Techniques**	1.1 Introduction to Herbarium: Definition, history, objectives and importance 1.2 Types of herbaria: National, regional, institutional and virtual herbaria 1.3 Major herbaria of India and the world 1.4 Role of herbaria in taxonomy, biodiversity, ecology and conservation 1.5 Herbarium equipment and materials 1.6 Methods of plant collection and field techniques 1.7 Ethical considerations and legal aspects of plant collection 1.8 Field notes and documentation techniques	8
	1b. Herbarium Preparation and Maintenance	1.9 Plant pressing methods and drying techniques 1.10 Poisoning and preservation methods 1.11 Mounting techniques for herbarium specimens 1.12 Herbarium label preparation and accessioning 1.13 Preservation of special plant groups 1.14 Common problems in herbarium maintenance	7

		1.15 Care, storage and maintenance of herbarium collections	
2. Advanced Herbarium Techniques And Applications	**2a. Identification and Digitization Techniques**	2.1 Identification of plants using floras, manuals and taxonomic keys 2.2 Nomenclature and herbarium citation methods 2.3 Preparation and maintenance of digital herbaria 2.4 Herbarium databases and cataloguing systems 2.5 Imaging and scanning techniques for herbarium specimens 2.6 Herbarium standards and international regulations 2.7 Curatorial practices and herbarium management	8
	2b. Applications and Modern Trends in Herbarium Science	2.8 Conservation and restoration of old herbarium specimens 2.9 Role of herbarium in environmental impact assessment 2.10 Herbarium applications in pharmacognosy and ethnobotany 2.11 Herbarium applications in climate change and biodiversity studies 2.12 Molecular approaches and DNA sampling from herbarium specimens 2.13 Preparation of thematic and teaching herbaria 2.14 Virtual herbarium and modern trends in herbarium science 2.15 Field visit/report writing and overall review of herbarium techniques	7

B.SC.-III BOTANY

SEMESTER –V

PRACTICALS BASED ON MAJOR ELECTIVE I: HERBARIUM TECHNIQUES

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practicals

1) Study of herbarium tools, equipment and field kit
2) Field visit for plant collection and field note preparation
3) Methods of plant pressing and drying
4) Preparation of blotters and plant presses
5) Mounting of herbarium specimens
6) Preparation of herbarium labels
7) Preservation techniques for delicate specimens
8) Preparation of herbarium sheets for grasses and aquatic plants
9) Identification of plant specimens using floras and keys
10) Study of major herbaria (virtual/physical visit)
11) Herbarium accessioning and cataloguing
12) Digitization and photography of herbarium specimens
13) Management and storage of herbarium specimens
14) Preparation of thematic herbarium collections
15) Submission of a mini-herbarium collection with field report

Suggested References

1. Jain, S.K. & Rao, R.R. – A Handbook of Field and Herbarium Methods.
2. Bridson, D. & Forman, L. – The Herbarium Handbook.
3. Lawrence, G.H.M. – Taxonomy of Vascular Plants.
4. Singh, G. – Plant Systematics: Theory and Practice.
5. Simpson, M.G. – Plant Systematics.
6. Woodland, D.W. – Contemporary Plant Systematics.
7. Radford, A.E. – Fundamentals of Plant Systematics.
8. Hyland, B.P.M. – Herbarium Handbook for Plant Identification.
9. Fosberg, F.R. & Sachet, M.H. – Manual for Tropical Herbarium Techniques.
10. Victor, J.E., Smith, G.F. & Van Wyk, A.E. – Herbarium Essentials.
11. Harris, J.G. & Harris, M.W. – Plant Identification Terminology: An Illustrated Glossary.
12. Stace, C.A. – Plant Taxonomy and Biosystematics.
13. International Association for Plant Taxonomy (IAPT) – International Code of Nomenclature.
14. Forman, L. & Bridson, D. – The Herbarium Handbook (Revised Edition).
15. Pandey, B.P. – Taxonomy of Angiosperms.
16. Sharma, O.P. – Plant Taxonomy.

B.SC.-III BOTANY

SEMESTER –V

MAJOR ELECTIVE I : INDUSTRIAL BOTANY AND APPLIED PLANT SCIENCES

Credits: 2; 2 Hours per week **Total : 30 Hours Marks: 40+10**

Course Objectives

To introduce students to the industrial applications of plants and plant products.

To provide knowledge about medicinal and aromatic plants and their commercial utilization.

To familiarize students with algal, fungal and fermentation industries.

To develop an understanding of digital botany, smart agriculture and precision farming.

To impart knowledge about pharmaceutical botany and herbal industries.

To create entrepreneurship skills related to herbal products, mushroom cultivation and agro-industries.

Course Outcomes

After successful completion of the course, students will be able to:
Identify economically important medicinal and aromatic plants.
Explain extraction methods and industrial uses of plant products.
Understand commercial cultivation of Spirulina and mushrooms.
Apply digital tools such as GIS, AI and IoT in agriculture.
Understand quality control and formulation of herbal medicines.
Develop basic entrepreneurial skills in the herbal and agro-based industries.

Module	Sub Module	Topics	Hours
Module I	**Medicinal and Aromatic Plants**	1.1 Traditional systems of medicine. 1.2 Active phytochemicals and secondary metabolites in plants. 1.3 Cultivation and processing techniques of medicinal plants [Phase 1: Cultivation- site and soil selection; Propagation; Growth conditions; Pest and weed management; Phase 2: Harvesting and primary processing-Harvesting, Cleaning, Garbling, Sizing/Cutting; Phase 3: Drying and storage-sun drying, shade drying, artificial drying; Packaging, Storage 1.4 Essential oils and extraction methods: Solvent Extraction: Jasmine and Rose. 1.5 Herbal cosmetics and nutraceuticals [Herbal Cosmetics-skin care: Aloe vera, hair care: Shikakai shampoo; Herbal Nutraceuticals- Functional Foods Spirulina]	8
	Microbial biotechnology [Algae and Fungi]	1.6 Spirulina cultivation and applications. 1.7 Fermentation technology 1.8 Industrial cultivation of yeast (Saccharomyces cerevisiae) 1.9 Vinegar production process. 2.0 Mushroom cultivation and marketing- Agaricus bisporus.	7
Module	**Digital Botany and**	2.1 AI and IoT in agriculture.	8

Module	Sub Module	Topics	Hours
II	**Smart Agriculture**	2.2 Precision farming and smart irrigation systems. 2.3 GIS and remote sensing applications in vegetation analysis. 2.4 Digital herbarium and plant databases. 3.5 Smart greenhouse management systems.	
	Pharmaceutical Botany	2.5 Pharmacognosy and crude drugs - Types of Crude Drugs, Classification, Common Sources, Evaluation and Quality Control. 2.6 Drug-yielding plant and plant-based pharmaceuticals-example Adulsa. 2.7 Standardization and quality control of herbal drugs. 2.8 Ayurvedic pharmaceutical industries in India.	7

B.SC.-III BOTANY

SEMESTER –V

PRACTICALS BASED ON MAJOR ELECTIVE I: INDUSTRIAL BOTANY AND APPLIED PLANT SCIENCES

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practical's

1. Study of crude drugs and their identification based on morphology, odor, color, and texture- example Clove, Cinnamon, Licorice, and Ginger.
2. Extraction of essential oils by the steam distillation method using orange peel/ mint leaves/ cloves.
3. Qualitative analysis of phytochemicals: alkaloids, tannins, flavonoids and saponins.
4. Preparation of herbal products: herbal shampoo, herbal face pack, herbal sanitizer and herbal tea.
5. Study of cultivation practices of medicinal plants [any two].
6. Cultivation and maintenance of Spirulina.
7. Demonstration of fermentation technique using Yeast.
8. Cultivation of Pleurotus sajor-kaju.
9. Digital data of plants using a mobile application/software.
10. Study of online plant databases and biodiversity portals.
11. Demonstration of GIS applications in vegetation mapping.
12. Introduction to AI-based plant disease identification tools.
13. Preparation of herbal formulations, for example, Triphala churna.
14. Quality evaluation of herbal products: moisture content (Glycyrrhiza glabra), ash value (Acacia catechu) and extractive value (Bacopa monnieri).
15. Study of packaging and labeling of herbal medicines.
16. Visit to herbal gardens/pharmaceutical industries/nurseries/mushroom cultivation unit or fermentation industry.

List of Recommended Books

Kokate, C. K., Purohit, A. P. and Gokhale, S. B. (2021). *Pharmacognosy*. 58th Edition. Nirali Prakashan, Pune.
Trease, G. E. and Evans, W. C. (2009). *Pharmacognosy*. 16th Edition. Saunders Elsevier, London.
Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Chapman and Hall, London.
Mukherjee, P. K. (2019). *Quality Control and Evaluation of Herbal Drugs*. Elsevier, New Delhi.
Chang, S. T. and Miles, P. G. (2004). *Mushrooms: Cultivation, Nutritional Value, Medicinal Effect and Environmental Impact*. CRC Press, Boca Raton.

Stanbury, P. F., Whitaker, A. and Hall, S. J. (2016). *Principles of Fermentation Technology*. 3rd Edition. Butterworth-Heinemann, Oxford.
Pelczar, M. J., Chan, E. C. S. and Krieg, N. R. (2010). *Microbiology*. Tata McGraw Hill, New Delhi.
Subba Rao, N. S. (2017). *Biofertilizers in Agriculture and Forestry*. 4th Edition. Oxford and IBH Publishing Co., New Delhi.
Rangaswami, G. and Bagyaraj, D. J. (2018). *Agricultural Microbiology*. PHI Learning Pvt. Ltd., New Delhi.
Palaniappan, S. P. and Annadurai, K. (2019). *Organic Farming: Theory and Practice*. Scientific Publishers, Jodhpur.
Dhaliwal, G. S. and Arora, R. (2016). *Integrated Pest Management: Concepts and Approaches*. Kalyani Publishers, Ludhiana.
Baser, K. H. C. and Buchbauer, G. (2015). *Handbook of Essential Oils: Science, Technology and Applications*. CRC Press, Boca Raton.
Pierce, F. J. and Nowak, P. (1999). *Aspects of Precision Agriculture*. ASA-CSSA-SSSA Publications, Madison.
Zhang, Q. (2016). *Precision Agriculture Technology for Crop Farming*. CRC Press, Boca Raton.
Chrispeels, M. J. and Sadava, D. E. (2003). *Plants, Genes and Crop Biotechnology*. Jones and Bartlett Publishers, Massachusetts.

B.SC.-III BOTANY

SEMESTER –V

PRACTICALS BASED ON VSC - II: MAJOR SPECIFIC HORTICULTURE (P)

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Course Objectives

To master specialized equipment and cultural practices

To integrate modern and artistic design systems

To analyze plant diversity and classification

To develop value-addition and processing skills

Course Outcomes

On successful completion of this course students will be able to;

Understand the importance of Horticulture and develop practical expertise in horticultural techniques for orchard establishment.

Gain skills to plan and manage commercial nurseries, garden, orchard; execute garden designs, and handle propagation for horticultural crops.

Demonstrate expertise related to various practices in a horticulture viz. technique of bonsai, Terrarium preparation, fruit preservation, floral decoration.

Comprehend knowledge and skills to get an employment or to become an entrepreneur in horticulture sector.

List of Practical's

1. Study of garden tools and implements.
2. Study of important vegetable crops (roots, stems, leaves, flowers, fruits and seeds)
3. Study of different types of mulches and their applications in vegetable crops production.
4. Study of irrigation methods (Drip, Sprinkler and Surface).
5. Study of Hydroponics technique for cultivation of horticulture crops.
6. Study of important commercial varieties of fruit plants (Mango, Banana, Citrus, Grape).
7. Study of special horticultural practices and their management: Pruning, Pinching, Disbudding, Deshooting, Staking, Desuckering, Netting, Defoliation, Bending of shoots, etc.
8. Study of Garden plants with their ornamental values:

   Trees: *Lagerstroemia*,Climbers:

   Bougainvillea /Pyrostegia venusta ;

   Foliage herb: *Dieffenbackia / Coleus*;

   Cactus: *Opuntia microdasys*;

   Succulents: *Sedum*;

   Palms: Foxtail palm;

   Hedge plant: *Ficus benjamina*;

   Edge plants: *Lantana*;

Lawns for sports: Bermuda grass.

9. Study of Bonsai technique.
10. Study of technique of Terrarium preparation.
11. Drawing of Garden layouts/ Landscapes
12. Demonstration of flower arrangement – Flower pot, Flower Bouquet and Floral Rangoli
13. Study of technique of fruit preservation-Amla candy and Tomato sauce.
14. Study the technique of preparation of floral drinks (*Clitoria ternatea*) and perfumes (distillation technique).
15. Visit to Garden/Orchard/ Vegetable farm.

Suggested Readings:

1. Handbook of Horticulture- K.L.Chadha (ICAR, New Delhi).
2. Fundamentals of Horticulture- J.B. Edmond, T.L. Senn, F.S. Andrews, and R.G. Halfacre.
3. Basic Horticulture -Jitendra Singh (Kalyani Publishers).
4. Plant Propagation Practices- James P. Hudson and F.W. Whitely.
5. Nursery Management- R.R. Sharma and M. Srivastav (International Book Distributors).
6. A Textbook of Pomology (Vol. I-IV)- T.K. Chattopadhyay.
7. Tropical and Subtropical Fruit Crops- S. Prasad and U. Kumar.
8. Production Technology of Fruit Crops - S.D. Singh (Kalyani Publishers)
9. Soil Fertility and Nutrient Management- S. Prasad and U. Kumar.
10. Principles of Plant Pathology- R.S. Singh (Oxford & IBH)
11. Post Harvest Technology of Fruits and Vegetables (Vol. I & II)- L.R. Verma and V.K. Joshi (Indus Publishing).
12. Floriculture in India- G.S. Randhawa and A. Mukhopadhyay (Allied Publishers).
13. Objective Horticulture- S. Prasad and U. Kumar.
14. Instant Horticulture - S.N. Gupta (20th Edition).

B.Sc.-III BOTANY

SEMESTER –V

OPEN ELECTIVE II : MUSHROOM CULTIVATION AND MARKETING

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course objectives

To facilitate self-employment.
To know the nutrient value of mushroom.
To study the morphology and types of Mushrooms.
To know the spawn production technique.
To learn the prospects and scope of mushroom cultivation in small scale industry.
To understand the diseases and post harvesting techniques of Mushrooms.

Course Outcomes

Students can start small scale industry of Mushroom cultivation.
Students studied the morphology and types of Mushrooms.
Students will be able produce spawn on their own.
Learned the prospects and scope of mushroom cultivation in small scale industry.
Studied the technique of Mushroom cultivation.
Understood the diseases and post harvesting techniques of Mushrooms.

Module	Sub-Module	Topic	Lectures Allotted
I	**Mushroom cultivation**	1.1 Introduction to Mushrooms 1.2 General characters of Mushrooms 1.3 Types of mushrooms: (Edible and Nonedible) 1.4 Nutrient profile of Mushrooms, Health benefits of mushroom, 1.5 Cultivation technology of Oyster Mushroom (Pleurotussajor-caju): Basic requirements for cultivation Oyster Mushroom, Substrate selection, bagging, spawning, incubation	15
II	**Mushroom Marketing**	2.1 Storage of Mushrooms: Storage of fresh mushrooms- short term storage and long term, storage of dried mushrooms. 2.2 Processing of Mushrooms: Canning, Dehydration etc 2.3 Market Analysis and Demand: Identifying target markets for fresh and processed mushrooms 2.4 Value-added Products a) Processing mushrooms: Dried, canned, and packaged products. b) Branding and marketing strategies for mushroom products 2.5 Mushroom recipes.	15

B.Sc.-III BOTANY

SEMESTER –V

PRACTICAL BASED OPEN ELECTIVE II : MUSHROOM CULTIVATION AND MARKETING

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Course Objectives

To analyze fungal biology and taxonomic diversity
To evaluate biochemical, nutritional, and medicinal values
To master substrate engineering and spawn technology
To standardize cropping, harvesting, and post-harvest operations
To build commercial enterprise and value-addition capabilities

Course Outcomes

Students differentiate toxic lookalikes from safe edible spe**cies**
Students explain the systemic health benefits of therapeutic fungi
Students produce high-yield sterile spawn matrices independently
Students manage complete commercial Oyster mushroom cropping cycles
Students stable shelf-ready value-added culinary products

Practical's

1. Study of External Characters of Mushrooms
2. Study of internal structure of mushroom
3. Study of different species of mushroom.
4. Study of edible mushrooms
5. Study of poisonous mushrooms
6. Photographic collection of different species of mushroom.
7. Study of equipments/instruments required for mushroom cultivation.
8. Study of Neutriceutical values of mushroom
9. Study of medicinal importance of mushroom.
10. Study of materials for compost preparation.
11. Preparation of spawn substrate and its storage.
12. Study of cultivation of Oyster mushroom.
13. Study of harvesting of mushrooms.
14. Study of any suitable method for mushroom preservation
15. Preparation of various mushroom dishes
16. Visit to mushroom production unit.

List of Recommended Books:

1. Handbook on Mushrooms by Nita Bahl Published by Oxford & IBH publishing Company.
2. Mushroom Cultivation by J.N. Kapoor published by ICAR, New Delhi.
3. A handbook of cultivated mushrooms by Dr. Ashok Ghanekar.
4. Handbook of Horticulture IARI, New Delhi.
5. Marimuthu, T. et al. (1991). Oster Mushroom. Department of Plant Pathology.Tamil Nadu Agricultural University, Coimbatore.
6. Nita Bhal. (2000). Handbook on Mushrooms. 2nd ed. Vol. I and II. Oxford and IBH Publishing Co.

Pvt. Ltd., New Delhi
7. Pandey R.K, S. K Ghosh, 1996. A Hand Book on Mushroom Cultivation. Emkey Publications.
8.Pathak, V. N. and Yadav, N. (1998). Mushroom Production and Processing Technology. Agrobios, Jodhpur.
9. Tewari Pankaj Kapoor, S. C. (1988). Mushroom Cultivation. Mittal Publication, New Delhi.
10. Tripathi, D.P. (2005) Mushroom Cultivation, Oxford & IBH Publishing Co.PVT.LTD, New Delhi.
11. V.N. Pathak, Nagendra Yadav and Maneesha Gaur, Mushroom Production and Processing Technology/ VedamsEbooks Pvt Ltd., New Delhi (2000).

बी.एस्सी.- ३ वनस्पतिशास्त्र
सत्र –५

मुक्त निवड विषय (Open Elective)II: आळंबी लागवड व विपणन

क्रेडिट : २ दर आठवड्याला तास : २ **एकूण तास : ३० गुण : ४० + १०**

अभ्यासक्रमाची उद्दिष्टे (Course Objectives)

स्वयंरोजगारासाठी विद्यार्थ्यांना सक्षम करणे.
मशरूमचे पोषणमूल्य जाणून घेणे.
मशरूमची रचना (Morphology) व विविध प्रकारांचा अभ्यास करणे.
स्पॉन (Spawn) निर्मिती तंत्रज्ञान समजून घेणे.
लघुउद्योग म्हणून मशरूम उत्पादनाच्या संधी व व्याप्ती जाणून घेणे.
मशरूमवरील रोग व काढणीनंतरच्या (Post-harvest) तंत्रांचा अभ्यास करणे.

अभ्यासक्रम निष्पत्ती (Course Outcomes)

विद्यार्थी मशरूम उत्पादनाचा लघुउद्योग सुरू करू शकतील.
विद्यार्थ्यांनी मशरूमची रचना व विविध प्रकारांचा अभ्यास केलेला असेल.
विद्यार्थी स्वतः स्पॉन तयार करू शकतील.
मशरूम उत्पादनाच्या संधी व लघुउद्योगातील व्याप्ती समजलेली असेल.
विद्यार्थ्यांनी मशरूम उत्पादनाची तंत्रे आत्मसात केलेली असतील.
मशरूमवरील रोग व काढणीनंतरच्या तंत्रांविषयी विद्यार्थ्यांना समज प्राप्त झालेली असेल.

घटक	उपघटक	ष्टवषय	घड्याळी तास
१	१.१ **आळंबीची ओळख**	**आळंबीची लागवड** 1.1 आळंबीची ओळख 1.2 आळंबीची सामान्य वैशिष्ट्ये 1.3 आळंबीचे प्रकार : (खाद्य व अखाद्य) 1.4 आळंबीचे पोषणमूल्य व आरोग्यदायी फायदे 1.5 ऑयस्टर आळंबी(Pleurotus sajor-caju) लागवड तंत्रज्ञान : ऑयस्टर आळंबी लागवडीसाठी मूलभूत आवश्यकता, सब्सट्रेटची निवड, बॅग भरणे , स्पॉनिंग व इन्क्युबेशन	१५
२	**आळंबी विपणन**	2.1 आळंबी साठवणूक :ताज्या आळंबीची साठवणूक – अल्पकालीन व दीर्घकालीन साठवणूक, वाळवलेल्या आळंबीची साठवणूक. 2.2 आळंबी प्रक्रिया :कॅनिंग, निर्जलीकरण (Dehydration) इत्यादी. 2.3 बाजारपेठ विश्लेषण व मागणी :ताज्या व प्रक्रिया केलेल्या आळंबी साठी लक्ष्यित बाजारपेठ ओळखणे. 2.4 मूल्यवर्धित उत्पादने : अ) आळंबी प्रक्रिया – वाळवलेली, डबाबंद (Canned) व पॅकेज्ड उत्पादने. ब) आळंबी उत्पादनांसाठी ब्रँडिंग व विपणन धोरणे. 2.5 आळंबी पाककृती	१५

बी.एस्सी.- ३ वनस्पतिशास्त्र
सत्र –५

मुक्त निवड विषय (Open Elective)II: आळंबी लागवड व विपणन

प्रात्यनिका वर आधारीत : आळंबी लागवड व विपणन

क्रेनडट: २. प्रात्यनिक तास: ६० (आठवड्याला ४ तास) **एकूण 50 गुण**

१. आळंबीच्या बाह्य वैष्टशष्ट्यांचा अभ्यास करणे.

२. आळंबीच्या अंतगणत रचनेचा अभ्यास करणे.

३. आळंबीच्या प्रजातींचा अभ्यास करणे.

४. खाण्यायोग्य आळंबीचा अभ्यास करणे.

५. विषारी आळंबीचा अभ्यास करणे.

६. आळंबीच्या विविध प्रजातींचे छायाचित्र संग्रहन करणे.

७. आळंबीच्या लागवडीसाठी आवश्यक असलेल्या उपकरणांचा/साधनांचा अभ्यास करणे.

८. आळंबीचे पोषक मूल्यांचा अभ्यास करणे.

९. आळंबी औषधी महत्त्वाचा अभ्यास करणे.

१०. कंपोस्ट तयार करण्यासाठी वापरल्या जाणाऱ्या साहित्यांचा अभ्यास करणे.

११. स्पॉन सब्स्ट्रेट तयार करणे त्याची साठवणूक करणे.

१२. ऑयस्टर आळंबी लागवडीचा अभ्यास करणे.

१३. आळंबी कापणीचा अभ्यास करणे

१४. आळंबी जतन करण्यासाठी कोणत्याही योग्य पद्धतीचा अभ्यास करणे.

१५. आळंबीपासून विविध खाद्यपदार्थ तयार करणे .

१६. आळंबी उत्पादन केंद्राला भेट.

B.Sc. III BOTANY

SEMESTER –V

ON-THE-JOB TRAINING (OJT)

(As per National Education Policy, 2020)

1. Course Title: **On-the-Job Training (OJT)**
2. Course Code: …….
3. Credits: **04**
4. Total Learning Hours: **120 Hours**
5. Semester: **Vth Semester**.
6. Course Type: Mandatory | Skill-based | Experiential Learning
7. Nature of Assessment: Internal Assessment Only
8. Total Marks: **100**

9. Course Rationale

In accordance with the National Education Policy (NEP) 2020 and the Internship/OJT guidelines of Shivaji University, Kolhapur, this course aims to integrate theoretical knowledge with real-life practical exposure. The On-the-Job Training (OJT) and Field Project provide undergraduate Botany students with hands-on experience in academic, research, industrial, ecological, and community-based settings, enabling holistic learning and skill development.

10.Course Objectives

The objectives of this course are to:

1. Provide experiential learning through direct engagement with professional work environments. 2. Enable application of botanical knowledge in laboratory, field, and industrial contexts.
3. Develop technical skills related to plant sciences, ecology, biodiversity, and applied botany.
4. Promote professional ethics, discipline, teamwork, and communication skills.
5. Enhance employability, entrepreneurship, and research aptitude among students.

Course Outcomes (COs)

Upon successful completion of the course, the learner will be able to:

1. Demonstrate hands-on skills in botanical field and laboratory techniques.
2. Apply theoretical concepts of Botany to practical situations.
3. Collect, document, analyze, and interpret botanical and ecological data.
4. Prepare a structured scientific OJT report.
5. Communicate findings effectively through oral presentation and viva-voce.

Nature of OJT

Students shall complete OJT in **any one** of the following approved areas: -

- Universities and Research Institutes
- Forest Department
- Environmental NGOs and Conservation Organizations
- Plant Tissue Culture and Biotechnology Laboratories
- Seed Testing, Nursery and Horticulture Units
- Herbal/ Pharmaceutical Industry
- Agro-based Industries
- Any other related with subject

Duration and Hour Distribution

Component	**Hours**
Orientation and Planning	10
On-the-Job Training	80
Data Collection, Analysis & Report Writing	20
Presentation and Viva-Voce	10
Total	**120 Hours**

Guidelines for Students

1. Students must obtain prior approval from the Department and Course Coordinator.
2. OJT must be carried out at a recognized organization/industry/institution.
3. Maintenance of a daily logbook/field diary is compulsory.
4. A completion certificate from the host organization is mandatory.
5. Students must follow institutional discipline and professional ethics.
6. Plagiarism in report writing is strictly prohibited.

OJT Report Structure

1. Title Page
2. Certificate from Host Organization
3. Student Declaration
4. Introduction of Organization / Study Area
5. Objectives of OJT / Field Project
6. Methodology / Nature of Work
7. Observations and Results
8. Discussion
9. Learning Outcomes and Skills Acquired
10. Conclusion
11. Photographs / Field Evidence
12. References

Scheme of Evaluation (Internal – 100 Marks)

Component	Marks
Attendance, Discipline & Logbook	30
OJT Report	30
Presentation / Seminar	20
Viva-Voce	20
Total	**100 Marks**

Detailed Evaluation Rubrics

A. Attendance, Discipline & Logbook (30 Marks)

Criteria	Excellent (26–30)	Good (21–25)	Satisfactory (16–20)	Poor (≤15)
Regularity & Punctuality	Fully regular	Minor lapses	Occasional absence	Irregular
Logbook Maintenance	Complete, neat	Minor errors	Incomplete	Poor
Professional Behaviour	Highly professional	Cooperative	Needs improvement	Unprofessional

B. OJT Report (30 Marks)

Criteria	Excellent	Good	Satisfactory	Poor
Structure & Organization	Scientific	Organized	Average	Poor
Content & Relevance	In-depth	Adequate	Limited	Poor
Data & Analysis	Accurate	Relevant	Basic	Inadequate
Language & Presentation	Clear	Minor errors	Average	Poor

C. Presentation / Seminar (20 Marks)

Criteria	Excellent	Good	Satisfactory	Poor
Clarity & Confidence	Excellent	Good	Average	Poor
Subject Knowledge	Thorough	Good	Basic	Inadequate
Use of Visual Aids	Effective	Adequate	Minimal	None

D. Viva-Voce (20 Marks)

Criteria	Excellent	Good	Satisfactory	Poor
Conceptual Understanding	Strong	Good	Basic	Poor
Application of Knowledge	Excellent	Good	Limited	Nil
Communication Skills	Clear	Adequate	Hesitant	Poor

Student Logbook / Field Diary Format (Mandatory)

Student Name: _____Roll No.: _____Semester: _____

College: _____OJT Organization: _____

Duration: From _____To _____

Date	Work Assigned	Practical / Field Work Done	Learning Outcome	Supervisor Signature

OJT Certificate Format CERTIFICATE

This is to certify that Mr./Ms. _____, Roll/ Exam No. _____, student of B.Sc. Botany, _____ College, affiliated to Shivaji University, Kolhapur, has successfully completed the On-the-Job Training (OJT) at _____ during the period from _____ to _____ as part of the 4 Credit Course under NEP 2020.

Date:

Name & Signature of Supervisor

Seal of Organization

ANNEXURE – I: STUDENT UNDERTAKING / DECLARATION

I, **Mr./Ms. _____**, Roll No. **, student of B.Sc. Botany, Semester V , *of* **_____**College**, affiliated to **Shivaji University, Kolhapur**, hereby declare that I have undertaken the **On-the-Job Training (OJT)** at **_____(Name of Organization)** during the period from _____ **to _____**as prescribed under the **4 Credit Course as per NEP 2020**.

I further declare that the work submitted by me is original, carried out honestly, and has not been submitted previously for any degree or diploma. I have followed all rules, safety norms and discipline of the host organization.

Date: _____

Signature of Student: _____

ANNEXURE – II: STUDENT PROFILE

- Name of Student:
- Roll No.:
- Programme & Semester: B.Sc. Botany, Semester
- College Name:
- Contact Number:
- Email ID:

B.SC.-III BOTANY SEMESTER-VI

MAJOR XI: PLANT BREEDING AND PLANT GENETIC RESOURCES MANAGEMENT

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course Objectives and Outcomes:

Course Objective:

To impart knowledge to the students on the principles and procedures of plant breeding in self- and cross-pollinated crops to develop the high yielding varieties / hybrids.

Course Outcomes: By the end of the course, the students will be able to

Learn breeding procedures in self- and cross-pollinated crops

Understand exploitation of heterosis utilizing male sterility and other methods

Study about the fundamentals of mutation breeding, and wide hybridization and their role in crop improvement.

Know the importance of Natural resources and its management strategies.

THEORY SYLLABUS (30 Lectures)

Module	Sub-Module	Topics	Lecture Periods
Unit-1. Plant Breeding	**1.1. Introduction to plant breeding and Selection Methods**	1. Definition, aim, objectives, and scope of plant breeding 2. Domestication, plant introduction, Quarantine; and Acclimatization of plants, germplasm, plant introduction agencies in India – National Bureau of Plant Genetic Resources (NBPGR) and merits and demerits of plant introduction. 3. Selection methods- i) Mass selection, ii) Pure line selection, iii) Clonal selection, procedure for evolving a variety by these selection methods, merits, demerits and achievements.	**08**
	1.2 Hybridization techniques in Plant breeding	1. Hybridization techniques: i) aims and objectives, ii) types of hybridization: in self-pollinated and cross-pollinated crops, iii) procedure / steps involved in hybridization, heterosis and hybrid vigour. 2. Male sterility – different types – genetic, cytoplasmic, and cytoplasmic genetic male sterility, application in crop improvement. 3. Mutation breeding, spontaneous and induced mutations, procedure of mutation breeding, applications, advantages, limitations, and achievements. 4. Experimental designs and biometrical techniques in plant breeding - Randomized block design, Analysis of variance, Assessment of variability, Hardy Weinberg Law of equilibrium.	**10**
Unit-2: Plant Genetic Resources Management	**2.1 Plant Genetic Resources (PGR)**	**1. Introduction:** Definition, scope, and objectives of PGR. **Centres of Diversity:** Vavilov's centres of origin and diversity, agro-biodiversity hotspots, Gene Pool	

		2. Germplasm Collection and Exploration: **Exploration Strategy:** Strategies for exploration and collection of cultivated and wild relatives. **Sampling Techniques:** Methods for collecting germplasm (random vs. targeted). **Evaluation:** Screening for biotic (pests, diseases) and abiotic stresses (drought, salinity).	**04**
	Unit 2.2.: Conservation Strategies (PGR Management)	1. **Ex situ Conservation:** Seed banks (short/medium/long-term), field gene banks, in vitro conservation, cryopreservation. 2. **In situ Conservation:** On-farm conservation, biosphere reserves, protected areas. 3. Importance of genetic conservation, Global network for genetic conservation and utilization in major crops of world, Institutes engaged in conservation and improvement of crop genetic resources, Wild relatives of crop plants, Gene banks, Gene sanctuaries.	**08**

B.SC.-III BOTANY

SEMESTER-VI

PREACTICALS BASED ON MAJOR XI, VA

PLANT BREEDING AND PLANT GENETIC RESOURCES MANAGEMENT

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practicals:

1. Study of methods of emasculation.
2. Breeding techniques in the crops of Malvaceae, Fabaceae and Poaceae.
3. To study the floral biology of self-pollinated and cross-pollinated species
4. Study of pollen germination and demonstration of incompatibility.
5. To study cross ability between cultivars.
6. Study of cytoplasmic male sterility in maize crop.
7. To study the effect of mutagens on germination, seedling growth.
8. Demonstration of different seed banks such as orchards.
9. Study of in-vitro conservation methods for vegetatively propagated crop plants.
10. Calculating mean, range, variance, and standard deviation to evaluate genetic variability within crops.
11. Study of Vavilov's centres of origin of crop plants.

12.13 Study of abiotic stress tolerance assessment in crop plants (drought/salinity/temperature)

14.15 Preparation of Project report on (any one of the following): –a) Seed bank

b) Collection of wild germplasm.

References

Allard, R.W. 1960. *Principles of Plant Breeding*. John Wiley and Sons, New York. Phundan Singh, 2006. *Essentials of Plant Breeding* . Kalyani Publishers, New Delhi. Poehlman, J.M. and Borthakur, D. 1995. *Breeding Asian Field Crops*. Oxford and IBH Publishing Co., New Delhi.

Sharma, J.R. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw Hill, Publishing Company Ltd., New Delhi.

Singh, B.D. 2006. *Plant Breeding: Principles and Methods*. Kalyani Publishers, New Delhi.

B.SC.-III BOTANY

SEMESTER-VI

MAJOR PAPER XII: PLANT DIVERSITY AND PALEOBOTANY

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course objectives

To introduce plant diversity and types and understand the importance of plant diversity.
To understand causes of loss of plant diversity and its measures.
To study the diversity of plants with respect to morphology and reproduction.
To enhance knowledge of conservation of plant diversity.
To study concepts of paleobotany and its importance.

Course outcomes

After successful completion of the course, students will be able to:
Understand types of plant diversity and its importance.
Recognize the difference between types of plants.
Understand methods of plant diversity conservation.
Know the concepts of paleobotany and its importance.

Module no.	Module	Submodule	Periods
1.	**1a. Introduction to plant diversity**	Plant diversity—Introduction, types (genetic, species and ecosystem) and importance. 1.2 Classification (Five-Kingdom System) 1.3 Plant kingdom—Cryptogams and Phanerogams, 1.4 Causes of loss of plant diversity and its measures.	5
	1b. Diversity of lower plants and gymnosperms	1.5 Morphology and diversity of lower plants, morphology and reproduction (excluding developmental stages of sex organs) of *Chara*	10
		1.6 Morphology and reproduction (excluding developmental stages of sex organs) of *Albugo.*	
		1.7 Morphology and reproduction (excluding developmental stages of sex organs) of *Anthoceros.*	
		1.8Morphology and reproduction(excluding developmental stages of sex organs) of *Adiantum.*	
		1.9 Morphology and diversity of gymnosperms, morphology and reproduction (excluding developmental stages) of *Gnetum.*	
2.	**2a. Conservation of Plant Diversity**	2.1 Conservation of Plant Diversity: Introduction 2.2 Types of conservation: In-situ and ex-situ conservation. 2.3 Social approaches to conservation (sacred grove) and plant diversity awareness programs. 2.4 Role of organizations in plant diversity conservation (IUCN, BSI, NBPGR).	8
	2b. Paleobotany	2.5Geological Time Scale, Contribution of Birbal Sahni to Palaeobotany. 2.6 Fossilization and fossil types. 2.7 Study of organ genera: *Lyginopteris* and *Enigmocarpon* Economic importance of fossils—fossil fuels and industrial raw materials and uses.	7

B.SC.-III BOTANY

SEMESTER-VI

PREACTICALS BASED ON MAJOR PAPER XII,VB

PLANT DIVERSITY AND PALAEOBOTANY

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practicals

1. Study of identification of algae: *Sargassum, Oscillatoria and Batrachospermum*.
2. Study of vegetative and reproductive structure of *Chara*.
4. Study of identification of fungi: *Stemonitis, Rhizopus, Aspergillus, Ustilago and Cercospora*.
5. Study of *Albugo* on Mustard
7. Study of identification of bryophytes: *Riccia, Sphagnum*.
8. Study of vegetative and reproductive structure of *Anthoceros.*
9. Study of identification of pteridophytes: Equisetum, *Psilotum, Lycopodium and Nephrolepis.*
10. Study of vegetative and reproductive structure of *Adiantum.*
11. Study of vegetative and reproductive structure of *Gnetum.*
12. Determination of frequency and density of different species in quadrates (list quadrates).
13. Study of plant species diversity on campus.
14. Study of fossil types as per theory.
15. Study of fossil *Lyginopteris* (permanent slide).
16. Study of fossil *Enigmocarpon* (permanent slide).
17. Collection and submission of herbarium of weeds (at least 10 specimens).

References

1. Vashishta BR, Sinha AK, and Singh VP (2013). Algae. S. Chand & Company Ltd. ISBN-81-219-3521-0
2. Singh V, Pande PC, and Jain DK (2003). A textbook of BOTANY. Rastogi Publication, Meerut. ISBN-81-7133-584-5.
3. Stephenson, Steven L. 2010. The Kingdom Fungi: An Introduction to Mushrooms, Molds, and Lichens, 1st Edition. Portland: Timber Press.
4. Sambamurty, A. V. S. S. 2005. A Textbook of Bryophytes, Pteridophytes, Gymnosperms, and Paleobotany. New Delhi: I K International Publishing House Pvt. Ltd.
5. Alexopoulos, C. J., C. W. Mims, and M. Blackwell. 2002. Introductory Mycology. New Delhi: Wiley India Pvt Ltd.
6. Singh, J. S. (2007). Plant Diversity and Conservation. Pub. Satish Serial Publishing House. ISBN: 978-8189304195.
7. Mishra, S. R. (2010). Textbook of Palaeobotany. Pub. Discovery Publishing House Pvt. Ltd. ISBN: 978-8183565561.
8. Sambamurty, A. V. S. S. (2011). A Textbook of Bryophytes, Pteridophytes, Gymnosperms, and Paleobotany. I. K. International Publishing House Pvt. Ltd. ISBN: 8188237450.
9. Singh, S. K. (2026). Gymnosperm and Paleobotany. Pub. Campus Books International. ISBN: 9788180301452.

Suggested readings

1. Fritsch, F.E. (1935). The Structure and Reproduction of the Algae. Volume I. Cambridge University Press, Cambridge
2. Sambamurty AVSS (2010). A textbook of algae. IK International Pvt. Ltd., New Delhi. ISBN- 81-88237-44-2.
3. Kumar HD (2011). Introductory Phycology. East West Press Pvt. Ltd., New Delhi. ISBN-81-85938962.
4. Henry, R. J. (2004). Plant Diversity and Evolution: Genotypic and Phenotypic Variation in Higher Plants. Wallingford, Oxon, GBR: CABI Publishing. ISBN: 97-80851-999-043.
5. Pandey, B. P. (2019). College Botany Vol. I. S. Chand Publications. ISBN: 978-8121905930

B.SC.-III BOTANY

SEMESTER-VI

MAJOR ELECTIVE PAPER NO. II: PLANT METABOLISM AND STRESS PHYSIOLOGY

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course Objectives

To provide comprehensive knowledge of plant metabolism, nitrogen metabolism, transpiration, and physiological processes involved in plant growth and development.

To develop understanding of plant stress physiology, including abiotic and biotic stress factors, stress responses, and adaptive mechanisms in plants.

To explain biochemical, physiological, molecular, and hormonal mechanisms involved in stress tolerance, nitrogen assimilation, and plant survival under adverse environmental conditions.

To enhance analytical, experimental, and applied skills related to plant physiology, stress management, and sustainable agricultural and environmental practices.

Course Outcomes

After successful completion of the course, students will be able to:

Explain the concepts of plant metabolism, nitrogen fixation, nitrate reduction, ammonia assimilation, and transpiration mechanisms in plants.

Analyze different types of plant stresses such as drought, salinity, temperature, and waterlogging, along with their physiological and biochemical impacts.

Describe the role of antioxidants, phytohormones, stress proteins, and adaptive mechanisms in developing stress tolerance in plants.

Apply knowledge of plant physiology and stress adaptation for improving crop productivity, stress management, and sustainable agricultural practices.

Module	Sub-module	Topics	Lectures
1 Plant Metabolism	**1. a: Nitrogen Metabolism**	1.1 Introduction to metabolism, anabolism and catabolism 1.2 Nitrogen Metabolism • Introduction and Importance of Nitrogen: Role of nitrogen in plant metabolism • Sources and Forms of Nitrogen: Atmospheric nitrogen, Soil nitrogen forms: nitrate (NO_3^-) and ammonium (NH_4^+) • Nitrogen Uptake by Plants: Uptake of nitrate and ammonium • Biological Nitrogen Fixation: Concept and significance of nitrogen fixation, Conversion of atmospheric nitrogen into usable form, Nif genes • Types of Nitrogen Fixation: Symbiotic nitrogen fixation, non-symbiotic nitrogen fixation • Nitrogenase Enzyme: Structure and function • Nitrate Reduction: Conversion of nitrate to nitrite and ammonia • Ammonia Assimilation: GS–GOGAT pathway, Reductive amination	10

	1. b: Transpiration	1.3 Transpiration: Introduction, Types, Mechanism: Starch- Sugar hypothesis, Significance	**5**
Module 2: Stress Physiology	**2. a: Basics of Plant Stress**	2.1 Concept of stress and strain; types of plant stress (abiotic and biotic); general stress responses 2.2 Water stress: drought and waterlogging; osmotic stress and osmotic adjustment 2.3 Temperature stress: heat, chilling, freezing; heat shock proteins 2.4 Salinity stress: causes, physiological effects and tolerance mechanisms	**7**
	2. b: Stress Tolerance and Adaptation	2.5 Antioxidant defence system: enzymatic and non-enzymatic antioxidants 2.6 Role of phytohormones in stress tolerance: ABA, ethylene, salicylic acid, jasmonic acid 2.7Morphological and anatomical adaptations to stress 2.8 Physiological and biochemical adaptations; compatible solutes and stress proteins 2.9Stress tolerance vs stress avoidance	**8**

B.SC.-III BOTANY

SEMESTER-VI

PRACTICALS BASED ON

MAJOR ELECTIVE PAPER NO. II PLANT METABOLISM AND STRESS PHYSIOLOGY

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practicals:

1. Demonstration of anabolism and catabolism in Plants
2. Study of nitrogen deficiency symptoms in plants
3. Detection of nitrate in plant tissue (Qualitative test for nitrate using diphenylamine)
4. Detection of ammonium in plant extract (Qualitative test using Nessler's reagent)
5. Estimation of nitrate in plant material (Simple colorimetric method)
6. Demonstration of nitrate reductase activity (*In vivo* assay using leaf discs)
7. Study of root nodules in leguminous plants
8. Study of transpiration using cobalt chloride paper.
10. Effect of drought and waterlogging stress on seed germination
11. Effect of salinity stress on seed germination
12. Demonstration of heat stress on membrane permeability
13. Assay of enzymatic antioxidants (e.g. catalase activity) under stress conditions
14. Demonstration of non-enzymatic antioxidants (e.g. TPC) in plant tissues
15. Comparative study of stress tolerance and stress avoidance in plants

References:

1. Bhatla, S. C., & Lal, M. A. (2019). *Plant physiology, development and metabolism*. Springer Singapore.
2. Kochhar, S. L., & Gujral, S. K. (2020). *Plant physiology: Theory and applications* (2nd ed.). Cambridge University Press.
3. Taiz, L., & Zeiger, E. (2010). *Plant physiology* (5th ed.). Sinauer Associates.
4. Hopkins, W. G., & Hüner, N. P. A. (2009). *Introduction to plant physiology* (4th ed.). Wiley.
5. Salisbury, F. B., & Ross, C. W. (1992). *Plant physiology* (4th ed.). Wadsworth.
6. Sinha, R. K. (2003). *Modern plant physiology*. Narosa Publishing.
7. Gupta, D. K., & Palma, J. M. (Eds.). (2021). *Plant growth and stress physiology*. Springer.
8. Ahmad, P., & Prasad, M. N. V. (Eds.). (2012). *Abiotic stress responses in plants: Metabolism, productivity and sustainability*. Springer.
9. Raju, D., Rajendran, R. A., & Singh, V. P. (Eds.). (2024). *Phytohormones in abiotic stress*. CRC Press.
10. Peerzada, Y. Y., Shabir, A., & Hakeem, K. R. (Eds.). (2023). *Advances in plant nitrogen metabolism*. CRC Press.

11. Khan, M. N., Mobin, M., Firoz, F., & Corpas, F. J. (Eds.). (2014). *Nitric oxide in plants: Metabolism and role in stress physiology*. Springer.
12. Bhattacharya, A. (2017). *Abiotic stress and physiological process in plants*. NIPA.
13. Rao, K. V. M., Raghavendra, A. S., & Reddy, K. J. (Eds.). (2006). *Physiology and molecular biology of stress tolerance in plants*. Springer.
14. "Plant stress physiology". (n.d.). CABI Publishing.
15. Ördög, V., & Molnár, Z. (n.d.). *Plant physiology* (PDF ed.). [unpublished].
16. Mauseth, J. D. (2017). *Botany: An introduction to plant biology* (6th ed.). Jones & Bartlett Learning.
17. Lambers, H., Chapin, F. S., & Pons, T. L. (2008). *Plant physiological ecology* (2nd ed.). Springer.
18. Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2005). *Biology of plants* (7th ed.). W.H. Freeman.
19. Kramer, P. J., & Boyer, J. S. (1995). *Water relations of plants and soils*. Academic Press.
20. Nobel, P. S. (2009). *Physicochemical and environmental plant physiology* (4th ed.). Academic Press.
21. Larcher, W. (2003). *Physiological plant ecology* (4th ed.). Springer.
22. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sinauer Associates.
23. Cramer, G. R., et al. (2011). *Plant adaptation to environmental stress*. Springer.
24. Zhang, J., & Jia, W. (2019). *Plant hormones and abiotic stress tolerance*. Wiley-Blackwell.

B.SC.-III BOTANY

SEMESTER-VI

MAJOR ELECTIVE PAPER NO. II EPIDEMIOLOGY AND CONTROL OF EMERGING CROP DISEASES

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course Objectives

To understand the principles, concepts, and scope of plant disease epidemiology.
To study the influence of climate change and environmental factors on plant disease development and spread.
To develop knowledge about sustainable and integrated approaches for management of emerging crop diseases.
To understand the epidemiology and management of vector-borne plant diseases affecting agricultural crops.

Course Outcomes

After successful completion of the course, students will be able to:

Explain the fundamentals, history, and importance of plant disease epidemiology in crop protection and food security.
Analyze the impact of climate change, rainfall variation, and extreme weather events on disease outbreaks and epidemic development.
Apply sustainable agricultural practices, biological control methods, and resistant varieties for disease management.
Describe the role of insect vectors, transmission mechanisms, and integrated disease management strategies in controlling vector-borne plant diseases.

Module No.	Module	Sub-Modul	Periods Allotted
1	A) Epidemiology	**1.1** Fundamentals of Plant Disease Epidemiology- a) Definition and scope of plant disease epidemiology b) Historical development of plant disease epidemiology c) Importance in crop protection and food security d) Disease cycle and epidemic development e) Types of plant disease epidemics	07
		1.2 Effect of Climate Change on Disease Epidemiology a) Climate change and its agricultural significance b) Effect of rising temperature on crop diseases c) Irregular rainfall and disease outbreaks d) Seasonal shifts in pathogen occurrence e) Effect of extreme weather events on disease development	08

2	B) Control of Emerging Crop Diseases	**2.1** Epidemiology under Sustainable Agriculture a) Sustainable agriculture and plant disease management b) Role of soil health in disease suppression c) Role of biocontrol agents like *Trichoderma*, in disease control. d) Farmer participation in disease monitoring e) Role of agricultural extension services f) Resistant crop varieties and disease epidemic	08
		2.2 Epidemiology of Vector-Borne Plant Diseases a) Introduction to vector-borne plant diseases b) Role of insects in disease spread Ex. Whitefly, Aphid, Leafhopper c) Transmission mechanisms of pathogens d) Vector ecology and population dynamics e) Vector management basics f) Integrated Disease Management (IDM)	07

B.SC.-III BOTANY

SEMESTER-VI

PRACTICALS BASED ON

MAJOR ELECTIVE PAPER NO. II: EPIDEMIOLOGY AND CONTROL OF EMERGING CROP DISEASES

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practicals

1.and 2. Preparation of CDA culture media and isolate the soil mycoflora.

3.and 4. Survey and Calculate the percent disease incidence of any one fungal disease.

5. Determine the fungal spore diameter by micrometry technique.

6.7. Study the sensitivity of the fungal pathogen to any one fungicide.

8. Study the properties and mode of action of any two fungicides on pathogen.

9. and 10. Study the Effect of temperature and pH on mycelial growth of fungal pathogen (In Vitro)

11. Study the technique of preparation of Biopesticides from plants.

12. Identification and Role of Insect vectors in disease transformation. (eg, as per theory)

13. Field Survey of Crop Diseases

Survey nearby agricultural fields and record:

- Crop name
- Disease observed
- Symptoms
- Stage of crop
- Severity of infection

14. Preparation of Disease Herbarium

Mount and preserve infected specimens with proper labelling.

15. listing of plant diseases from college campus or surrounding area.

Reference Book

Plant Pathology – by George N. Agrios
Introduction to Plant Disease Epidemiology – by Clive Gilligan
Plant Disease Epidemiology: Facing Challenges of the 21st Century
Plant Diseases and Their Management
Principles of Plant Pathology
Diseases of Crop Plants in India
Biological Control of Plant Diseases
Plant Virology
Vector-Mediated Transmission of Plant Pathogens
Climate Change and Plant Abiotic Stress Tolerance

B.SC.-III BOTANY

SEMESTER-VI

MAJOR ELECTIVE PAPER NO. II: MEASURES AND SUSTAINABLE USES OF PLANT DIVERSITY

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course Objectives

To introduce the concept and significance of plant diversity.

To understand various measures and assessment methods of plant diversity.

To study threats responsible for the loss of plant diversity.

To develop understanding of conservation strategies and sustainable utilization of plant resources.

To enhance awareness regarding biodiversity conservation programs and organizations.

Course Outcomes

Understand the concept, importance, and ecological significance of plant diversity in maintaining ecosystem balance and supporting human life.

Identify, classify, and describe different levels and types of plant diversity, including genetic, species, and ecosystem diversity.

Apply various quantitative and qualitative methods to assess and measure plant diversity in natural and managed ecosystems.

Analyze the factors and anthropogenic threats responsible for the loss of plant diversity, including habitat destruction, overexploitation, invasive species, and climate change.

Evaluate and propose strategies for the conservation and sustainable utilization of plant resources, including in situ and ex situ conservation methods.

Recognize national and international biodiversity conservation programs, policies, and organizations, and understand their roles in promoting plant diversity conservation.

Develop critical thinking and ethical awareness about biodiversity conservation and promote responsible use of plant resources in daily life and professional practices.

Module No.	Module	Submodule	Periods
I	**Introduction to Plant Diversity**	1.1 Plant diversity—Concept, scope and importance. 1.2 Levels of biodiversity—Genetic, species and ecosystem diversity. 1.3 Types of plant diversity—Alpha, Beta and Gamma diversity. 1.4 Methods and indices for measuring plant diversity (species richness, Shannon-Wiener index, Simpson index; similarity index – Jaccard index).	8
	Threats to Plant Diversity	1.6 Causes of loss of plant diversity—Deforestation, habitat destruction, urbanization and pollution. 1.7 Climate change and invasive alien species. 1.8 Overexploitation of medicinal and economically important plants. 1.9 Red Data Book and endangered plant species.	7

II	**Sustainable Uses of Plant Diversity**	2.1 Sustainable utilization of plant diversity—Concept, principles and importance. 2.2 Economic importance of plant diversity in food, agriculture, forestry, medicine and industry. 2.3 Sustainable harvesting and management of medicinal and forest plant resources. 2.4 Role of traditional knowledge and indigenous communities in sustainable use of biodiversity. 2.5 Agro-biodiversity and sustainable agriculture practices.	8
	Management and Conservation Approaches	2.6 Sustainable use of non-timber forest products (NTFPs). 2.7 Ecotourism and biodiversity-based livelihood opportunities. 2.8 Biodiversity laws, policies and benefit-sharing mechanisms. 2.9 Role of community as well as individual participation in biodiversity management and conservation.	7

B.SC.-III BOTANY

SEMESTER-VI

PRACTICALS BASED ON

MAJOR ELECTIVE PAPER NO. II: MEASURES AND SUSTAINABLE USES OF PLANT DIVERSITY

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practicals

1-3 Calculate diversity indices (Shannon-Wiener index, Simpson index, Jaccard similarity index) by using given data.

4 .Study of plant species diversity in college campus by quadrat method.

5.Identification of endangered and endemic plant species.

6.Preparation of herbarium of locally available plant species.

7. Study of sacred groves and conservation practices.

8.Study of non-timber forest products (any five)

9.Determination of frequency and density of different species in quadrats (list quadrat)

10 To study IUCN categories with suitable examples.

12-13 Study of endemic plants (Any five).

14.Collection and submission of wild fruits (Any five).

15Field visit to botanical garden/nature reserve/ nursery/Sacred grove etc.

Suggested References

1. Sharma, P.D. – *Ecology and Environment*.
2. Singh, J.S. & Singh, S.P. – *Forest Ecology of India*.
3. Odum, E.P. – *Fundamentals of Ecology*.
4. Krishnamurthy, K.V. – *An Advanced Textbook on Biodiversity*.
5. Kumar, H.D. – *Biodiversity and Sustainable Conservation*.

B.SC.-III BOTANY

SEMESTER-VI

MAJOR ELECTIVE PAPER NO. II: INDUSTRIAL PHYTOTECHNOLOGY AND AGRO-BOTANY

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course Objectives

To introduce concepts and applications of biofertilizers and biopesticides.
To understand principles and practices of organic farming.
To study industrial production and commercialization of biofertilizers.
To develop knowledge regarding integrated pest management and sustainable agriculture.
To encourage entrepreneurship in agro-based industries.

Course Outcomes

After successful completion of the course, students will be able to:
Explain the types and importance of biofertilizers and biopesticides.
Demonstrate methods used in organic farming.
Understand mass production and formulation of microbial products.
Apply integrated pest management techniques.

Module	Sub Module	Topics	Hours
Module I Biofertilizers and Biopesticides	**Biofertilizers**	1.1 Definition, types, and importance of biofertilizers. 1.2 Nitrogen-fixing biofertilizers and phosphate-solubilizing microorganisms. 1.3 Mass production and application methods of biofertilizers. 1.4 Bacterial, fungal, viral (NPV), and botanical pesticides.	8
	Biopesticides	1.5 Definition, importance, and types of biopesticides. 1.6.Bacterial, fungal, viral (NPV), and botanical pesticides. 1.7 Integrated Pest Management (IPM).	7
Module II Organic Farming Biofertilizer and Biopesticide	**Organic Farming**	2.1 Principles and components of organic farming. 2.2 Crop rotation and mixed cropping. 2.3 Organic certification and standards. 2.4 Organic farming in India: scope and challenges.	8
	Biofertilizer and Biopesticide Industries	2.5 Commercial production methods. 2.6 Formulations and quality control. 2.7 Storage and marketing. 2.8 Government policies and schemes. 2.9 Entrepreneurship opportunities in biofertilizer industries.	7

B.SC.-III BOTANY

SEMESTER-VI

PRACTICALS BASED ON MAJOR ELECTIVE PAPER NO. II
INDUSTRIAL PHYTOTECHNOLOGY AND AGRO-BOTANY

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practical's

1. Study the process of manufacturing biofertilizer (Rhizobium) and seed application.
2. Isolation (serial dilution technique) and pure culture of Trichoderma from soil on PDA.
3. Demonstration of biopesticide application- seed treatment method example-Trichoderma.
4. To study the technique of preparing Vermicompost and vermiwash.
5. Preparation of organic manure (garden compost).
6. Soil quality analysis- any two from pH, Soil Texture, organic matter content.
7. Water Quality analysis- any two from Salinity (EC)/Adsorption Ratio (SAR)/.pH Level/ Specific Ion Toxicity/ Nutrients/ Bicarbonates/Carbonates
8. Demonstration of Integrated Pest Management (IPM) techniques.
9. Preparation of liquid organic manures: Jeevamrut/ Beejamrut/ Panchagavya.
10. Cultivation and uses of Green manure- Crotalaria juncea, or Sunn Hemp.
11. Mulching techniques and moisture conservation studies.
12. Demonstration of the Hydroponic technique.
13. To study the process of seed certification.
14. Botanical Name, family, chromosome number, center of origin, nature of propagation, list of wild relatives, distribution of species of the Sugarcane crop.
15. Study tour/visit to organic farms, biofertilizer units, or agro-industries.

List of Recommended Books

Subba Rao, N. S. (2017). *Biofertilizers in Agriculture and Forestry* (4th ed.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Rangaswami, G., & Bagyaraj, D. J. (2018). *Agricultural Microbiology* (3rd ed.). PHI Learning Private Limited, New Delhi.

Palaniappan, S. P., & Annadurai, K. (2019). *Organic Farming: Theory and Practice*. Scientific Publishers, Jodhpur, India.

Gaur, A. C. (2010). *Handbook of Organic Farming and Biofertilizer Technology*. Agro Botanica, Bikaner, India.

Dhaliwal, G. S., & Arora, R. (2016). *Integrated Pest Management: Concepts and Approaches*. Kalyani Publishers, Ludhiana, India.

Sathe, T. V. (2004). *Biopesticides and Bioagents*. Daya Publishing House, New Delhi.

Vayas, R. V. (2008). *Biofertilizer Technology*. Agrotech Publishing Academy, Udaipur, India.

ICAR. (2021). *Handbook of Organic Farming*. Indian Council of Agricultural Research (ICAR), New Delhi.

B.SC.-III BOTANY

SEMESTER-VI

PRACTICALS BASED ON VSC - III: MAJOR SPECIFIC: HERBAL TECHNOLOGY

Credits: 2; 4Hours per week **Total 60 Hours** **Marks: 50**

Course Outcome

On successful completion of this course students will be able to; Start their own small-scale business.
Understand the use of medicinal plants in the Pharma industries. Able to formulate and evaluate various herbal products.
Practice the collection, cultivation, and processing of medicinal plants.
Understand knowledge of marketing, demand, and commercial aspects of herbal products.

Course objectives

To inculcate entrepreneurship.
To understand the traditional knowledge of herbal formulations.
To know the importance of herbal Plants and their uses in human life. To study the herbal plant product preparation techniques.
To learn the prospects and scope of herbal products in small scale industry. To study various methods to develop diverse herbal products.

List of Practicals

1. Study of Botanical name, morphology, part used and medicinal importance of Plants. Shatavari (Root), Gulvel (Stem), Neem (Leaf), Amla (Fruit).
2. Determination of Total Ash content in sample (any suitable plant material in Powder form). Microscopic examination of herbal powders with respect to identify calcium oxalate crystals, and starch grains in crude drug.
3. Determination of moisture content using the "Loss on Drying" (LOD) method in Amla.
4. Study of preliminary phytochemical tests (Alkaloids, Tannins and Saponins) in alcohol soluble and water-soluble crude extracts.
5. Herbal Preparations of Churn (Triphala Churna) and Kadha/Decoction (Adulsa).
6. Herbal Preparations of Hair oil (Maka) and Shampoo (Ritha, Shikakai).
7. Herbal Preparation of perfume from any suitable plant material.
8. Herbal preparation of face mask from any suitable plant material.
9. Herbal preparation of cold cream using Turmeric and Sandalwood.
10. Herbal preparation of Mouth Freshener using (Guava leaf/ Green Cardamom) or any suitable plant material.
11. Preparation of an antimicrobial ointment using Neem or *Aloe vera*.
12. Preparation of herbal tea with any suitable plant material.
13. Morphological/Biochemical test for drug adulteration.
    Morphological: Mustard (*Brassica juncea + Argemone mexicana*); Black Pepper (*Piper nigrum + Carica papaya*)

Biochemical: Haladi (*Curcuma longa + Zea mays*); Coconut (*Cocos nucifera+ Solanumtuberosum*).

14. Report on visit to any Medicinal Garden/Pharma Industries or Institution/Herbal Cosmetic Industry (Separate Handwritten report to be submitted by student).
15. Submission of herbarium specimen of any suitable and common medicinal plant. (any five plant specimen).

Suggested Reading:

Agrawal, S. S., & Paridhavi, M. (2012). *Herbal Drug Technology* (2nd ed.). Hyderabad, India: Universities Press (India) Private Limited / Orient Blackswan.

Ansari, S. H. (2010). *Essentials of Pharmacognosy* (4th ed.). New Delhi, India: Birla Publications Pvt. Ltd.

Balick, M. J. and Cox, P. A. (1996). *Plants, People, and Culture: The Science of Ethnobotany*, Scientific American Library, New York.

Chopra R.N., S. L. Nayar and I. C. Chopra, 1956. Glossary of Indian medicinal plants C.S.I.R, New Delhi.
Dey and Raj Bahadur,1984. The indigenous drugs of India, Kanny, Lall. International Book Distributors.
Jain, S.K. (1991). Dictionary of Indian Folk Medicine and Ethnobotany. Deep Publications, New Delhi.

Jain, S.K. (2010). *Ethnobotany in India: A Status Report*. Deep Publications, New Delhi.

Jain, S.K. and Mudgal, V. (1999). *A Handbook of Ethnobotany*. Bishen Singh Mahendra Pal Singh, Dehradun.

Kokate, C. K., Purohit, A. P., & Gokhale, S. B. (2008). *Pharmacognosy* (42nd ed.). Pune, India: Nirali Prakashan.

Martin, G. J. (2004). *Ethnobotany: A Methods Manual*, Earthscan, London.

Mukherjee, P. K. (2002). *Quality Control of Herbal Drugs: An Approach to Evaluation of Botanicals*. New Delhi, India: Business Horizons Pharmaceutical Publishers.

Nadkarni and Nadkarni (1976) Indian Materia Medica Vol. I and II
Patel, R., Farooqui, N. A., & Bajwa, B. S. (2020). *Pharmacognosy and Phytochemistry – I* (1st ed.). Lucknow, India: Thakur Publication Pvt. Ltd.

Rangari, V. D. (2009). *Pharmacognosy & Phytochemistry (Volume I & II)* (2nd ed.). Nashik, India: Career Publications.

Rastogi, P.R. and Mehrotra, B.N. (1993). *Compendium of Indian Medicinal Plants*. CDRI, Lucknow.

Reddy, K. Y., & Reddy, P. V. M. (2025). *Herbal Drug Technology* (1st ed.).

B.SC.-III BOTANY SEMESTER-VI

SEC III: BIOSTATISTICS

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course Objectives

To introduce the fundamental concepts, scope and importance of biostatistics in biological and botanical sciences.
To familiarize students with different types of biological data and standard methods of data collection and sampling.
To develop skills in organizing, classifying, tabulating and graphically presenting biological data.
To understand measures of central tendency, dispersion and variation with biological relevance.
To provide basic knowledge of correlation and commonly used statistical tests for analysis of biological data.

Course Outcomes

After successful completion of the course, students will be able to:
Explain the role and applications of biostatistics in botany and biological research.
Identify different types of data and apply appropriate methods of data collection and sampling.
Organize biological data using classification, tabulation, and graphical representation techniques.
Calculate and interpret measures of central tendency and dispersion in biological datasets.
Understand variation in biological data and its significance in plant populations.
Analyse relationships between variables using correlation techniques.
Apply basic statistical tests such as t-test and chi-square test for biological data interpretation.

Module	Sub Module	Topic	Periods
Module 1 Fundamentals of Biostatistics & Data Handling	**1(a)** Introduction and Data Collection	1.1 Definition, scope and importance of Biostatistics 1.2 **Types of Data:** Qualitative, Quantitative, Structured, Unstructured, Semi-structured, Time series, Spatial data, Big data 1.3 **Methods of data collection:** Census method and Sampling methods: Simple random, Stratified, Systematic, Cluster, Non-random sampling	7
	1 (b) Data Presentation	1.4 **Classification of Data:** Based on:- Nature, Source, Sensitivity, Purpose, Structure, Time-frame and Accessibility 1.5 **Tabulation of data:** Simple, Double and Complex tabulation 1.6**Graphical representation of data for frequency distribution:** Dot plots, Bar graph, Line graph, Circle graph, Histogram and frequency polygon	8
Module 2 Variability & Statistical Tools	**2 (a)** Measures of Central Tendency; Dispersion and Variation	2.1 **Measures of central tendency:** Definition, merits and demerits of Mean, Median and Mode with suitable example. 2.2 **Measures of dispersion and Variation:** Definition, Merits and Demerits of - Range, Standard deviation, Coefficient of variation with suitable example	8

	2 (b) Correlation and Statistical Testing	2.3 **Concept and types of correlation:** Positive, Negative, Zero 2.4 Karl Pearson's Correlation 2.5 Introduction to t-test and chi-square test with suitable example	7

B.SC.-III BOTANY

SEMESTER-VI

SEC III: BIOSTATISTICS

Credits: 2; 4 Hours per week **Total :60 Hours : 50 Marks**

Practicals

1. Collection and classification of plant data into qualitative and quantitative types
2. Organization and tabulation of any suitable data
3. Bar graph representation of categorial plant data
4. Dot plot and line graph representation of any suitable data
5. Graphical representation of categorical data: Pie chart depicting any suitable data
6. Frequency distribution analysis using histogram and polygon

7&8. Determination of measures of central tendency

9. Calculation of range and standard deviation of any suitable data
10. Calculation of coefficient of variation for any suitable data
11. Find out Karl Pearson's Correlation between two botanical traits
12. Analysis of t-Test to compare any suitable data
13. Analysis of Chi-Square test for observed vs. expected frequency of suitable data

14 and 15. Integrated data analysis project: recording, tabulation, graphing and statistical analysis of any suitable data

Reference Books:

1. Rosner, B. (2016). *Fundamentals of biostatistics* (8th ed.). Cengage Learning.
2. Pagano, M., & Gauvreau, K. (2018). *Principles of biostatistics* (2nd ed.). CRC Press.
3. Zar, J. H. (2010). *Biostatistical analysis* (5th ed.). Pearson.
4. Motulsky, H. (2014). *Intuitive biostatistics: A nonmathematical guide to statistical thinking* (3rd ed.). Oxford University Press.
5. Field, A. (2018). *Discovering statistics using IBM SPSS Statistics* (5th ed.). Sage Publications.
6. Gupta, S. C., & Kapoor, V. K. (2014). *Fundamentals of mathematical statistics* (11th ed.). Sultan Chand & Sons.
7. Khan, I. A. (2018). *Biostatistics: Basic concepts and methodology for health science* (2nd ed.). CBS Publishers & Distributors.
8. Indrayan, A. (2017). *Medical biostatistics* (3rd ed.). Chapman and Hall/CRC.
9. Gupta, M. P., & Bharti, A. C. (2017). *Biostatistics and research methodology*. Jaypee Brothers Medical Publishers.
10. Ganguli, B. (2000). *Statistical methods: Concepts, applications and computation*. World Press.
    Triola, M. F. (2018). *Elementary statistics* (13th ed.). Pearson.
11. Bland, M. (2015). *An introduction to medical statistics* (4th ed.). Oxford University Press.
12. Salkind, N. J. (2017). *Statistics for people who (think they) hate statistics* (6th ed.). Sage Publications.

B.SC.-III BOTANY

SEMESTER VI

IKS II, MAJOR SPECIFIC: ETHNOBOTANY

Credits: 2; 2 Hours per week **Total : 30 Hours** **Marks: 40+10**

Course objectives

Upon completing a course in Ethnobotany, students are expected to:
Understand Cultural-Plant Interactions: Explain the relationships between human cultures, ecosystems, and plant selection for food, medicine, poison, ritual, and religion.
Identify Medicinal Plants: Know specific plant taxa used by people, particularly in traditional medicine and home remedies.
Evaluate Conservation: Appreciate the role of traditional knowledge in the conservation of useful plants.
Develop Research Skills: Apply qualitative research methods to conduct ethnomedical surveys.

Course Outcomes

Ethnobotany contributes to the broader POs of a Botany or Life Science program:
Environmental Awareness: Understand the impact of plant diversity on societal and environmental issues and the need for sustainable development.
Economic Botany Application: Apply knowledge of ethnobotany to agriculture, pharmacology, and industry.
Ethical Practices: Understand the ethical, social, and legal issues regarding intellectual property rights of indigenous knowledge.

Module	Sub Module	Topic	Periods
Module 1 Concept and scope, methods of research in ethnobotany	**1(a) Concept and scope**	1.1 Introduction 1.2 History of Ethnobotany (Ayurveda, Siddha and Unani) 1.3 Concept of Ethnobotany 1.4 Scope of Ethnobotany 1.5 Importance of Ethnobotany 1.6 Ethnobotany as an Interdisciplinary Science; Ethnotaxonomy, Ethnoecology, Ethnopharmacology, Ethnomedicine, Ethnotoxicology, Archaeoethnobotany, Paleoethnobotany, Ethnohorticulture, Ethnomycology, Ethnoforestry, Ethnoagroforestry, Ethno Medico Botany	7
	1 (b) Methods of research in Ethnobotany	1.7 Introduction 1.8 Types of ethnobotanical research methods. 1.8.1 Ethnobotanical field work 1.8.2 Ethnobotanical study with the help of herbaria 1.8.3 Ethnobotanical study with the aid of literature 1.8.4 Archaeological remains and ethnobotany 1.8.5 Sculptures on temples 1.8.6 Folklore in ethnobotanical work	8
Module 2 Tribals and ethnomedicines, Conservation of sacred plants	**2 (a) Tribals and ethnomedicines**	2.1 Introduction 2.2 Ethno medicine. 2.3 Methods of preparation of traditional medicines Maceration, Infusion, Digestion, Decoction, Percolation. 2.4 Advantages and disadvantages of traditional herbal medicine.	8
	2 (b) Conservation of sacred plants	2.5 Introduction 2.6 Importance of sacred groves in biodiversity conservation 2.7 Sacred groves of Maharashtra 2.8 Threats to sacred groves 2.9 Spiritual plant species: Bargad (*Ficus bengalensis*), Pipal (*Ficus religiosa*), Banana (*Musa* spp.), Tulsi (*Ocimum sanctum*), Doob (*Cynodon dactylon*), Pati (*Artemisia vulgaris*), Dhatura (*Datura alba* and *D.stramonium*), Bel (*Agle marmelos*)	7

B.Sc. III BOTANY
SEMESTER –VI
FIELD PROJECT
(As per National Education Policy, 2020)

1. Course Title: Field Project in Botany

2. Course Code: (To be assigned by the University)

3. Credits: 02 Credits

4. Total Learning Hours: 30 Hours

5. Course Type: Research / Field Study | Experiential Learning

6. Nature of Assessment: Internal Assessment

7. Total Marks: 50 Marks

Course Rationale

Field-based research is an essential component of botanical education. The Field Project enables students to conduct systematic studies on plant diversity, ecology, conservation, and applied botany. It develops research aptitude and field observation skills among students.

Course Objectives
The objectives are:

1. To train students in botanical field survey techniques.
2. To develop skills in plant identification and ecological observation.
3. To introduce students to data collection and scientific documentation.
4. To promote awareness of biodiversity and conservation.
5. To encourage independent research and report writing.

Course Outcomes (COs)

Students will be able to:

1. Conduct field surveys and ecological observations.
2. Identify plant species and record habitat characteristics.

3. Collect and analyze ecological data.
4. Prepare a scientific field project report.
5. Present research findings effectively.

Suggested Field Project Areas
Students may work on topics such as:

- Plant Diversity of a region
- Ethnobotanical study of medicinal plants
- Weed diversity in agricultural fields
- Wetland plant ecology
- Forest biodiversity survey
- Nursery management practices
- Conservation of rare plants
- Study of crop diseases
- Any other suitable topic related to subject

Duration

Component	Hours
Project Planning	5
Field Survey & Data Collection	35
Data Analysis	10
Report Writing	5
Presentation & Viva	5
Total	**60 Hours**

Field Project Report Format

1. Title Page
2. Certificate
3. Student Declaration
4. Introduction
5. Objectives
6. Study Area Description
7. Materials and Methods
8. Observations / Data
9. Results
10. Discussion
11. Conclusion
12. Photographs / Field Evidence
13. References

Component	Marks
Field Work & Attendance	15
Data Collection & Analysis	10
Project Report	15
Presentation & Viva-Voce	10
Total	**50**

Field Project Certificate Format

CERTIFICATE

This is to certify that Mr./Ms.---------- , Roll/ Exam No. , student of B.Sc.III Botany, ---------- College, affiliated to Shivaji University, Kolhapur, has successfully completed the Field Project entitled as ----------during the academic year as part of the 2 Credit Course under NEP 2020.

Date:

Name & Signature of Supervisor Seal of Organization

Details of Practical Examination

A. Every candidate must produce a certificate from Head of the Dept. in his/her college, stating that he/she has completed practical course in satisfactory manner as per guidelines laid down by Academic Council on the recommendations of Board of Studies in Botany. The student should record his/her observations and report of each experiment should be written in the journal. The journal is to be signed periodically by teacher in charge and certified by Head of the Department at the end of year. Candidates have to produce their certificated journal and tour report at the time of practical examination. Candidate is not "allowed to appear" for the practical examination without a certified journal/a certificate from Head of Botany Dept. regarding the same.

B. Practical Examination shall be of Five hours duration and shall test a candidate in respect of the following.

1. Practical study of external and internal structures of different plant types and their classification. Making temporary stained preparations and identification.
2. Identification and setting of physiological and biochemical experiments.
3. Study of plant families as per syllabus.
4. Spotting of the specimens as per syllabus.

Botanical Excursions:

One teacher along with a batch not more than 20 students be taken for botanical excursion to places of Botanical interest, one in each term. If there are female students in a batch of twenty students, one additional lady teacher is permissible for excursion. Each excursion will not be more than SEVEN days during college working days. T.A. and D.A. for teachers and non-teaching staff participating in excursions should be paid as per rules. Tour report duly certified by teacher concerned and Head of the Department should be submitted at the time of practical examination.

Practical Course:

B. Sc. III Botany Practical course is to be covered in one hundred sixty five practicals. These practicals are to be performed by the students. Each practical is to be supplemented by permanent slides, preserved/fresh specimens/materials, charts, herbarium sheets, etc. wherever necessary.

C. OTHER FEATURES:

1. INTAKE CAPACITY / NUMBER OF STUDENTS:

As per university rules.

2. TEACHERS QUALIFICATIONS:

- As prescribed by norms.

- However, required number of core faculty should be given for particular course along with paper wise and Specialization wise work load allocation.
- Work load details should be as per Apex body/UGC/State Govt./University norms.
- The Board of studies should clearly mention the required Books, Journals and specific Equipment necessary for the Course.

(A) LIBRARY: Library be equipped with the required Reference and Text Books, Journals and Periodicals for higher and advanced studies as per stated in revised syllabus and approved by BOS.

(B) SPECIFIC EQUIPMENTS: T.V., V.C.R. V.C.P., L.C.D., Overhead Projector, Computers and necessary software and operating systems etc. are necessary to run the course.

(C) LABORATORY SAFETY EQUIPMENTS:

1. Fire extinguishers at least two sets in each laboratory of 600 sq. ft. Area.
2. Leakage of gases be avoided.
3. First aid kit be made available.
4. Sugar/Glucose –500gm pack- a pinch of sugar and a cup of drinking water in hypoglycemic condition or in extreme weakness of student or a person concerned.

B) GENERAL SAFETY RULES FOR LABORATORY WORK

1) List of equipment's needed for Laboratory Safety:

1. Fire extinguisher
2. First Aid Kit
3. Good earthing and insulated wirings for electrical supply.
4. Emergency exit
5. Apron and goggles wherever necessary
6. Fuming Chambers
7. Masks flows and shoes while handling hazardous chemicals & gases (Good valves, manometers and regulators for gas supply)
8. Operational manuals for instruments (handling to be made as suggested.)
9. Rules of animals and blanks ethics.
10. Leakage of gases to be avoided.
11. Cylinders or flow pipes to handle Acids.
12. No weighing for NaOH and hygroscopic substances.
13. Stabilized supply in the laboratory.

There Is No Substitute for Safety

1. Any injury no matter how small, it must be reported to teacher immediately.
2. a) In case any chemical enters your eyes go immediately to eye- wash facility and flush your eyes and face with large amount of water. b) For acid or phenol split, do not use water instead put some bicarbonate.

3. In case of fire, immediately switch of all gas connections in the laboratory and pour sand on the source of fire or cover it with asbestos or cement sheet.
4. While leaving laboratory, make sure that gas, water taps and electricity are switched off.
5. Remove your lab coat. Gloves and clean your hands before leaving laboratory.
6. Make your workplace clean before leaving the laboratory.
7. Keep your hands away from your face, while working in laboratory.
8. Each laboratory must have a first aid box.
9. Know what to do in case of emergency - e.g. (a) Know the place of fire extinguisher and first aid box.
10. Don't use cell phones in the laboratory. (a) Remember important phone numbers

3) DO's

1. Always wear lab coat, shoes in the laboratory. Every student must have their weight box, a napkin etc.
2. Maintain separate record book for each subject.
3. Keep your belongings at the place allotted for the same.
4. Maintain silence, order, cleanliness and discipline in the laboratory.
5. Work at the place allotted to you or specially used for certain operations.
6. Keep the working table clean.
7. Handle the laboratory equipment, glassware and chemical with great care.
8. Use only required quantities of material and apparatus of essential size.
9. Perform the test in their proper order.
10. Know the location of eye wash fountain and water shower.
11. Minimize your exposure to organic solvents.
12. The Metal like sodium should be kept under kerosene or liquid paraffin layer in a vessel with a cork stopper.
13. Sodium metal should be cut on dry filter paper. The cut off pieces of sodium should be immediately collected in a vessel containing kerosene or liquid paraffin.
14. Always pour acid into water when diluting and stir slightly.
15. All operations involving poisonous flammable gases and vapours should be carried out in the flame chamber (with exhaust facility)
16. Ladies should avoid wearing saree. If it is there, apron is essential.

DON'T

1. Don't work alone in the laboratory
2. Don't leave the glass wares unwashed.
3. Don't take apparatus, chemicals out of lab.
4. Don't leave any substance in a vessel or bottle without label.
5. Don't weigh the reagent directly on the balance pan.

6. Don’t throw the cut off pieces of sodium metal in sink or water. Transfer it immediately in its container.
7. Don’t take sodium metal with hands. Use forceps.
8. Don’t panic and run in case of fire. Use the fire extinguishers or sand buckets.
9. Don’t breathe the vapours of organic solvents.
10. Don’t pour any unused reagent back in its stock bottle.
11. Don’t eat or drink any food in laboratory.
12. Don’t use inflammable solvents like benzene, ether, chloroform, acetone and alcohol around flame.
13. Don’t distil to dryness.
14. Don’t exchange stoppers of flasks and bottles containing different reagents.
15. Don’t leave reagent bottle lying on the table.
16. Don’t disturb the order of reagent bottles in which they are placed.
17. Don’t bring reagent on your working table from the general shelf.
18. Don’t throw burning matchstick into dustbin.
19. Don’t leave the laboratory without permission.

5) LABORATORY / FIELD WORK CARE AND SAFTY FOR BOTANY STUDENTS:

- Unnecessary wastage of plant material during practicals should be avoided.
- During study tour / personal collection, more emphasis be given on study of plants in nature and collection of wild plants should not be carried out.
- If at all the collection of the plant material in needed, it should be carried out under supervision of concerned teacher. Collection of poisonous plants / poisonous mushrooms should be avoided.
- Oral intake of unknown plant material, out of curiosity, during practical or collection tour is strictly prohibited.
- If there is any allergic reaction while handling the plants / plant parts / pollen grains / fungal specimens it should be immediately brought to the notice of the concerned teacher and reported to the registered medical purloiner.Wearing of hand gloves (and mask) is essential while handling poisonous plants / herbarium sheets / toxic and hazardous chemicals / reagents / strong acids / strong alkalis during the experiment should be made with vacuum pipette / auto pipette / burette under the supervision of concerned teacher / lab assistant.
- Highly inflammable organic solvents (alcohol, acetone etc.) should not be kept in vicinity of spirit lamp.
- The laboratory safety measures adopted for handling of hazardous chemicals in chemistry practicals should be followed for conducting practicals in plant biochemistry / microbiology.
- Operational manuals for equipments such or centrifuge, autoclave, spectrophotometer should be

followed.

- In case of minor injuries, preliminary treatment should be undertaken with the help of first aid kit available in the laboratory. In case of serious injury, concerned teacher should be immediately contacted for consultation to the physician.
- The instruction reports for breeding, experimentation will be submitted in a week period. (Which are laid down by Ministry of Social Justice & Empowerment and Ministry of Environment and Forests, Govt. of India).

Program learning Outcomes

- PLO1. Students will able to Recognize morphology of reproductive organs and development in the reproduction of angiosperms.
- PLO2. Students will able to identify the plants
- PLO3. Students will be able to understand the methods to present a scientific research paper.
- PLO4. Students will be able to identify the natural resources in the Western Ghats, India. Also, student will understand the recent biotechnological advances in the biology.
- PLO5. Students will be able to explain the various stress factors in the plants and also to effects of stress factors on the plant and to overcome these factors.
- PLO6. Students will be able to explain the skills of bio-fertilizer production, herbal preparations, breeding techniques and different analytical techniques used in the plant science.