



ESTD: 1962
NAAC A⁺⁺ Grade
CGPA 3.52

M. SC. BOTANY REVISED SYLLABUS
(AS PER NATIONAL EDUCATION POLICY 2020)

FROM JULY 2023

DEPARTMENT OF BOTANY
SHIVAJI UNIVERSITY, KOLHAPUR

Revised Syllabus for the Master of Science in Botany, Shivaji University, Kolhapur
(National Education Policy 2020)

Applicable from academic year 2023 – 2024 (July 2023) for M.Sc. Part I and Part II (Botany) as per Resolution No. dated of Board of Studies in Botany and Resolution No.dated of Academic Council of Shivaji University, Kolhapur.

1. **Title:** M. Sc. Botany, Shivaji University, Kolhapur Revised Syllabus as per NEP 2020 and as per GR No.: NEP-2022/CR No. 09/VISHI-3/SHIKANA dated 16.05.2023
2. **Faculty:** Faculty of Science and Technology.
3. **Year of implementation:** For M. Sc. I (Semester I and Semester II): From July 2023 and for M. Sc. II (Semester III and Semester IV): From July 2024.
4. **Preamble:** Education is fundamental for achieving full human potential, developing an equitable and just society and promoting national development. Providing universal access to quality education is the key to India's continued ascent and leadership on the global stage in terms of economic growth, social justice and equality, scientific advancement, national integration and cultural preservation. Universal high-quality education is the best way forward for developing and maximizing our country's rich talents and resources for the good of the individual, the society, the country and the world. India will have the highest population of young people in the world over the next decade and our ability to provide high-quality educational opportunities to them will determine the future of our country.

Higher education plays an extremely important role in promoting human as well as societal well-being and in developing India as envisioned in its Constitution—a democratic, just socially-conscious, cultured and human nation upholding liberty, equality, fraternity and justice for all. Higher education significantly contributes towards sustainable livelihood and economic development of the nation. As India moves towards becoming a knowledge economy and society, more and more young Indians are likely to aspire for higher education.

India has tremendous biodiversity, genetic as well as of species and ecosystems which is a biological capital of our country. It contains over 7 per cent of the world's biodiversity on 2.5 per cent of the Earth's surface. This diversity can be attributed to the vast variety of landforms and climates resulting in habitats ranging from tropical to temperate, and from alpine to desert.

The number of plant species in India is estimated to be over 45,523 representing about 11.8 per cent of the world's flora. It is estimated that 32% of Indian plants are endemic to the country and found nowhere else in the world. Among the plant species the flowering plants have a much higher degree of endemism, a third of these are not found elsewhere in the world. There are 17,527 species, 296 subspecies, 2215 varieties, 33 subvarieties and 70 forma, altogether 20,141 taxa of angiosperms under 2991 genera and 251 families in India, representing approximately 7% of the described species in the world. About 5725 species of flowering plants are broadly considered as endemics and represent 33.5% of the flora, of which, 3471 species are found in the Himalayas, 2051 in the Peninsular India and 239 in Andaman & Nicobar Islands. Gymnosperms are

woody perennials, either shrubs or trees. There are 58 taxa growing in wild under 15 genera and 8 families in India. Though they are lesser in number, provide timber, wood, resins, tars and turpentine. Estimated number of pteridophytes (fern and fern-allies) are about 1200 taxa under 204 genera are distributed in different biogeographic regions of India. The Eastern Himalaya and the Northeast India with about 845 taxa in 179 genera, representing approximately 67% of the pteridophytes known from the country, followed by southern India, including Eastern and Western Ghats, with 345 taxa in 117 genera and Northern India, including Western Himalaya, with 340 taxa in 101 genera. Bryophytes less known group of plants, comprising about 2800 species, is the second largest group of green plants in India, next only to the angiosperms. About 16 genera and 678 species are endemic to India. Liverworts are represented by ca. 850 species under 140 genera and 52 families. Lichens are a symbiotic association of fungi and algae and constitute a dominant component of epiphytic and saxicolous vegetation. At present about 2021 species of lichens in 248 genera are known to occur in India. Fungi range from microscopic organisms to huge solid bodies. Approximately 14,500 species in 2300 genera are found in India of which ca. 3500 species are endemic. Algae represented by over 6500 species in ca. 666 genera, they are found growing in a variety of habitats ranging from fresh water, marine, terrestrial and to soil. Of which 1924 species are endemic to the country. The major portion of Indian algal flora accounting for ca. 390 genera and 4500 species followed by terrestrial algae (125 genera and 615 spp.); soil algae (80 genera and 1500 spp.); marine algae (169 genera and 680 spp.).

5. General objectives of the course:

a. Programme outcomes:

- i) **Rational thinking:** To check assumptions for their accuracy and validity.
- ii) **Biodiversity awareness:** To understand the local and global issues of environment and its sustainable development.
- iii) **Continuous learning:** To develop ability to engage independently on the context of human society and technological changes.
- iv) Solving problems related to food scarcity.

b. Course outcomes:

- i) Working knowledge of the basic concepts of Botany i. e. cellular, ecological, molecular, physiological, ecological organizations and evolutionary biology of algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms.
- ii) Students will learn several biophysical techniques such as electrophoresis, microscopy, biostatistics, bioinformatics, centrifugation, chromatography, spectroscopy, radioisotope and culture techniques.
- iii) Identification and understanding of basic concepts, plant diseases and several processes related to physiology, ecology, cell and molecular biology and biochemistry of plants under stress conditions.
- iv) Identification and classification of algae, fungi, bryophytes, pteridophytes, gymnosperms, angiosperms; evolution of reproductive structures, phylogeny and interrelationship of the selected genera.
- v) Understanding of basic concepts of population and how individuals of a population interact with the ecosystem.
- vi) Knowledge of plant pathology, identification of disease, their causal organisms, symptomology and defence mechanism of the plants against selected diseases.

- vii) Study of organs, their development, experimental embryology, apomixes and its types, polyembryony, experimental induction of polyembryony, palynology and its role in horticulture, agriculture and oil exploration programs.
 - viii) Understanding the processes of natural selection, migration, mutation, genetic drift and variation and application of this knowledge in crop improvement.
 - ix) Acquisition of skills required for the production of disease-free plants, development of hybrids, development of plants with novel traits. Intellectual property rights, their importance, ecological risks and ethical concerns.
 - x) Commercial storage products, knowledge and value-added structural components and information about active components.
6. The entire course of M. Sc. (Botany) will be of **four Semesters** spread over two years.
 7. Pattern of Examination: The examinations will be conducted **semester wise for both theory as well as practical courses.**
 8. **Fee structure:** As per Shivaji University guidelines.
 9. **Eligibility criteria for Admission:** B. Sc. in Botany.
 - a. A student shall be held eligible for admission to the M. Sc. Course in Botany who has passed the B. Sc. examination with Botany as a principal subject from Shivaji University, Kolhapur and also has passed the entrance examination conducted by the University.
 - b. A student from other university shall be eligible who qualifies entrance examination of Shivaji University and scores minimum 55% (B⁺) marks in the subject at the B. Sc. with Botany as a principal subject or with Botany at B. Sc. III level.
 - c. While preparing merit list, only the marks of entrance examination will be considered.

10. Medium of instruction: English

11. Structure of course:

Sr. No.	Course/Title	Nature	Credits	Marks
Semester I				
1.	Major Mandatory Course – I Biology and Diversity of Algae, Fungi and Bryophytes	Theory	4	100
2.	Major Mandatory Course – II Biology and Diversity of Pteridophytes, Gymnosperms and Palaeobotany	Theory	4	100
3.	Major Mandatory Course – III Tools and Technique	Theory	2	50
4.	Major Mandatory Course – IV	Practical	2	50
5.	Major Mandatory Course – V	Practical	2	50
6.	Major Elective Course – I	Theory	2	50
7.	Major Elective Course – II	Practical	2	50
8.	Research Methodology	Theory	4	100
Total Credits and Marks			22	550
Semester II				
9.	Major Mandatory Course – I Angiosperm Systematics	Theory	4	100
10.	Major Mandatory Course – II Cell and Molecular Biology	Theory	4	100

11.	Major Mandatory Course – III Structure, Development and Reproduction of Plants	Theory	2	50
12.	Major Mandatory Course – IV	Practical	2	50
13.	Major Mandatory Course – V	Practical	2	50
14.	Major Elective Course – I	Theory	2	50
15.	Major Elective Course – II	Practical	2	50
16.	On Job Training (OJT)/ Field Project (FP)	OJT/FP	4	100
Total Credits and Marks			22	550
Semester III				
17.	Major Mandatory Course – I Cytogenetics and Crop Improvement	Theory	4	100
18.	Major Mandatory Course – II Biotechnology and Genetic Engineering	Theory	4	100
19.	Major Mandatory Course – III Plant Ecology and Evolution	Theory	2	50
20.	Major Mandatory Course – IV	Practical	2	50
21.	Major Mandatory Course – V	Practical	2	50
22.	Major Elective Course – I	Theory	2	50
23.	Major Elective Course – II	Practical	2	50
24.	Research Project	RP	4	100
Total Credits and Marks			22	550
Semester IV				
25.	Major Mandatory Course – I Plant Physiology and Metabolism	Theory	4	100
26.	Major Mandatory Course – II Plant Pathology	Theory	4	100
27.	Major Mandatory Course – III	Practical	2	50
28.	Major Mandatory Course – IV	Practical	2	50
29.	Major Elective Course – I	Theory	2	50
30.	Major Elective Course – II	Practical	2	50
31.	Research Project	RP	6	150
Total Credits and Marks			22	550
Total Credits and Marks (I+II+III+IV)			88	2200

- a. In relation to elective courses, the student has to select any one of the following specializations (theory + practical) in the semester I. The same elective specialization will be continued in further semester II, III and IV.
1. Angiosperm Taxonomy
 2. Cytogenetics and Plant Breeding
 3. Energy, Ecology and Environment
 4. Mycology and Plant Pathology
 5. Plant Biotechnology
 6. Plant Physiology
- b. Temporarily suspended specializations:
1. Marine Botany
 2. Palaeobotany

12. Scheme of teaching and examination:

- a. Each unit in theory course shall comprise 15 lectures, each of 60 minutes' duration and there shall be four lectures per theory course per week.
- b. Each practical course shall be of three hours' duration.
- c. Library/ Reference-work/ Excursion/ Field work/ Seminar/ Group Discussion/ Project work will be organized every week.
- d. Entire course of M. Sc. Botany will be of **2200** marks. Every Semester will be of 550 marks.
- e. Examination of each 4 credit **theory course** shall be of **100 marks** (80 university examination + 20 internal assessment) and 2 credit **theory course** shall be of **50 marks** (40 university examination + 10 internal assessment). University examination of 80 marks (3 hours' duration) will be conducted at the end of each Semester. University examination of 40 marks (2 hours' duration) will be conducted at the end of each Semester Internal assessment of 20 and 10 marks will be done before the semester examination during each semester.
- f. Examination of each practical course shall be of 50 marks (40 marks' university examination + 10 marks' internal assessment). University examination of 40 marks will be conducted at the end of each semester. Internal assessment of 10 marks will be done before the semester examination during each semester. At the end of 3rd and 4th semester project work will be evaluated for 100 and 150 marks, respectively.
- g. The question paper of theory course (80 marks) will consist of seven questions, carrying 16 marks each, of which the student shall have to attempt **five** questions. The last question will be **compulsory** consisting of short notes. The question paper for theory course (40 marks) will consists of seven questions carrying 8 marks each, of which the student shall have to attempt **five** questions. The last question will be **compulsory** consisting of short notes.

13. Standard of passing: There will be separate passing for theory courses (University examination and internal assessment) and practical courses. Minimum 40% marks will be required for passing separately for theory and practical courses.

14. Nature of Question paper and scheme of marking for 4 credits (80 Marks):

Q.1.	Based on Unit I	–	16 Marks
Q.2.	Based on Unit II	–	16 Marks
Q.3.	Based on Unit III	–	16 Marks
Q.4.	Based on Unit IV	–	16 Marks
Q.5a.	Based on Unit I	–	8 Marks
Q.5b.	Based on Unit II	–	8 Marks
Q.6a.	Based on Unit III	–	8 Marks
Q.6b.	Based on Unit IV	–	8 Marks
Q.7a-f.	Based on all units	–	16 Marks

15. Nature of Question paper and scheme of marking for 2 credits (40 Marks):

Q.1.	Based on Unit I	–	8 Marks
Q.2.	Based on Unit II	–	8 Marks
Q.3.	Based on Unit I	–	8 Marks
Q.4.	Based on Unit II	–	8 Marks
Q.5a.	Based on Unit I	–	4 Marks
Q.5b.	Based on Unit II	–	4 Marks
Q.6a.	Based on Unit I	–	4 Marks
Q.6b.	Based on Unit II	–	4 Marks
Q.7a-f.	Based on all units	–	8 Marks

16. Other Features:

- i) Intake capacity/ Number of students at M. Sc. I will be 50 per year.
- ii) The student may take exit after successful completion of M. Sc. I (Semester I & II) and acquire a certificate of 'PG Diploma in Botany'. **Such student may join M. Sc. part II within next five years after exit.**

17. General guidelines:

- i) There shall be at least a short tour (up to 3 days) and a long tour (not exceeding 10 days) per year for all M. Sc. I and M. Sc. II students. The long tour may be arranged to a region out of the state covering various Botanical Regions/ Research Institutes/ Centres and Universities. Tours are the part of curriculum and are obligatory to each student, failing which they will not be considered eligible to appear for the practical examination. Under unavoidable circumstances, if the student fails to attend the tour, he/ she has to produce justifiable evidence for not attending the tour. However, in lieu of tour the candidate will have to complete the work assigned by the Department.
- ii) If there are female students in a batch of sixteen, one additional lady teacher is permissible for excursion. T.A. and D.A. for teachers and non-teaching staff participating in the excursions should be paid as per the rules.
- iii) Following documents will have to be produced by each student at the time of practical examination (at the end of each Semester):
 - a. Submission of a laboratory journal of practical records.
 - b. Submission of a tour report (**in his/ her own handwriting**) duly signed by the concerned teacher is mandatory.

18. Important instructions:

- a. **On Job Training /Field Project:** Every student shall go for on job training or field project in semester II. The same work will be evaluated in the department at the end of semester.
- b. **Research Project:** Every student will have to work for research project in semester III and IV. The same work will be evaluated in the department at the end of semester III as well as semester IV. Project report shall be submitted in hard bound form and there will be presentation at the time of evaluation.

M. SC. PART – I (SEMESTER - I)
MAJOR MANDATORY COURSE - I (THEORY) [4 CREDITS]
BIOLOGY AND DIVERSITY OF ALGAE, FUNGI AND BRYOPHYTES

[TOTAL LECTURES: 60]

UNIT I: ALGAE **[15]**

- ❖ Origin, evolution and trends in classification of Algae; Evolution of Chloroplast in Algae; Outline of Robert E. Lee (2008) classification of algae.
- ❖ Thallus organization, types of reproduction and evolution of sexual reproduction in algae
- ❖ Occurrence and distribution, thallus organization, cell structure and reproduction of algal classes: Cyanophyceae, Rhodophyceae, Chlorophyceae, Ulvophyceae, Charophyceae, Euglenophyceae, Phaeophyceae, Xanthophyceae and Bacillariophyceae.

UNIT II: FUNGI **[15]**

- ❖ Origin and evolution of fungi.
- ❖ Classification of fungi by Ainsworth (1973).
- ❖ Biodiversity and Taxonomy of following phyla up to the level of order:
Chytridiomycota: Chytridiales; **Zygomycota:** Glomales; **Ascomycota:** Taphrinales, Xylariales and Pezizales; **Basidiomycota:** Aphyllophorales, Uredinales, Ustilaginales Phallales and Nidulariales; **Oomycota:** Saprolegniales and Peronosporales; **Hypochytridiomycota:** Hypochytriales; **Labyrinthulomycota:** Labyrinthulales; Plasmodiophoromycota Plasmodiophoromycetales; **Dictyosteliomycota:** Dictyostelliales; **Myxomycota:** Stemonitales.

UNIT III: BRYOPHYTES **[15]**

- ❖ Recent classification of Liverworts (Stotler & Stotler, 2000); Hornworts (Renzaglia, & Vaughn, 2000) and Mosses (Buck & Goffinet, 2000).
- ❖ Distribution, habit, morphology, reproduction, phylogeny and interrelationship of Classes: **Marchantiophyta: Marchantiopsida:** Sphaerocarpaceae, Marchantiales and Ricciales. **Jungermanniophyta: Jungermanniopsida:** Fossombroniales, Metzgeriales, Jungermanniales and Porellales.
- ❖ **Anthocerotophyta: Anthocerotopsida:** Anthocerotales, Notothyladales
- ❖ **Bryophyta: Takakiopsida:** Takakiales; **Sphagnopsida:** Sphagnales; **Polytrichopsida:** Polytrichales, Tetraphidales; **Andreaeopsida:** Andreaeales; **Bryopsida:** Dipsacales, Encalyptales.

UNIT IV: **[15]**

- ❖ Culture, Cultivation and methods of preservation of Algae, Fungi and Bryophytes
- ❖ Role of Algae in human welfare; Algae as a Source of Biofuel and Phytoremediation
- ❖ Industrial and Biotechnological applications of Algae
- ❖ Economic importance and Industrial applications of Fungi
- ❖ Economic and Ecological significance of Bryophytes

REFERENCES BOOKS:

ALGAE:

- ❖ **Bellinger, E.G. and D.C. Sigeo (2010).** *Freshwater Algae: Identification and Use as Bioindicators*. A John Wiley & Sons, Ltd, Publication.
- ❖ **Chapman, V.J. and D. J. Chapman (1965).** *The Algae*
- ❖ **Desikachary, T.V. (1972).** *Taxonomy and Biology of Blue -green algae*
- ❖ **Fritsch, F. E. (1965).** *Structure and Reproduction of Algae*
- ❖ **Gangulee, H.C. and A. K. Kar (1992).** *College Botany Vol. III*
- ❖ **Kumar, H.D. and H. N. Singh (1971).** *Textbook of Algae*
- ❖ **Pandey, B. P. (1994).** *Textbook of Botany – Algae*
- ❖ **Rogers, K. (2011).** *Fungi, Algae and Protistis*. Britannica Educational Publishing
- ❖ **Sahoo D and Seckbach J. (2015).** *The Algae World*. Springer Science
- ❖ **Sharma, O.P. (2011).** *Textbook of Algae*
- ❖ **Vashista, B. R. (1995).** *Botany for degree students-Algae*
- ❖ **Lee R.E. (2008).** *Phycology*, 4th Edition Cambridge University Press

JOURNALS:

- ❖ Phykos
- ❖ Phycologia
- ❖ Seaweed Research
- ❖ Journal of Indian Botanical Society
- ❖ Indian Journal of Marine Biology

FUNGI:

- ❖ **Ainsworth, G. G. and A.S. Sussman.** *The Fungi Vols. I, II, III, IV- A and IV-B*
- ❖ **Alexopoulos C.J., Mims C.W., Blackwell M. (2007).** *Introductory Mycology* (Fourth Edition) Wiley India Pvt. Ltd
- ❖ **Bessey, E. A. (1967).** *Morphology and Taxonomy of Fungi*
- ❖ **Dayal (1995).** *Aquatic Fungi of India*
- ❖ **Gangulee, H.S. and A. K. Kar (1992).** *College Botany Vol. I*
- ❖ **Mundkur B.B. and M.J.Trimukchar (1952).** *Ustihlaginales of India*
- ❖ **Sharma, O.O. (1989).** *Textbook of Fungi*
- ❖ **Sparrdo F.K. (1960).** *Aquatic phycomycetes*
- ❖ **Subramanan, C. V. (1971).** *Hyphomycetes*
- ❖ **Thind K. S. (1977).** *The Myxomycetes of India*

BRYOPHYTES:

- ❖ **Buck, WR & Goffinet, B. (2000).** *Morphology and classification of mosses*, pp 71-123 in Shaw, AJ & Goffinet, B. (eds). (2000). *Bryophyte Biology*. Cambridge University Press.
- ❖ **Cavers, R. (1964):** Inter-relationship of Bryophytes
- ❖ **Chopra, R. N. and P. K. Kumar (1988)** *Biology of Bryophytes*.
- ❖ **Crandall-Stotler, B & Stotler, R. (2000).** *Morphology and classification of the Marchantiophyta*, pp 21-70 in Shaw, AJ & Goffinet, B. (eds). (2000). *Bryophyte Biology*. Cambridge University Press.

- ❖ **Goffinet, B. and A.J. Shaw (2009)** *Bryophyte Biology*. Cambridge University Press
- ❖ **Parihar, N. S. (1959):** *An introduction to Embryophyta. Vol. I –Bryophyta*
- ❖ **Ram Udar (1976):** *Bryology in India*
- ❖ **Renzaglia, KS & Vaughn, KC. (2000).** *Anatomy, development and classification of hornworts*, pp 1-20 in Shaw, AJ & Goffinet, B. (eds). (2000). *Bryophyte Biology*. Cambridge University Press.
- ❖ **Smith, G. M. (1955):** *Cryptogamic Botany Vol. II*
- ❖ **Vanderpoorten, A. and B. Goffinet (2009).** *Introduction to Bryophytes*. Cambridge University Press
- ❖ **Vashishta B.R., Sinha A.K. and Adarsh Kumar (2011,2016).** *Botany for Degree Students-Part III Bryophyta*. Revised Edition 2011, Reprint 2016 S, Chand Publishing
- ❖ **Vashishta, B.R. (1996):** *Botany for degree students –Bryophyta*
- ❖ **Watson, E.V, (1963):** *British Mosses and Liverworts*
- ❖ **Watson, E.V, (1964):** *The Structure and life of Bryophytes*

WEB LINKS

- ❖ <https://www.algaebase.org/>
- ❖ <https://www.mycobank.org/>
- ❖ <http://www.fungifromindia.com/fungiFromindia/buildPage.php?page=databases>
- ❖ <https://www.anbg.gov.au/bryophyte/classification-identification.html>

M. SC. PART – I (SEMESTER - I)
MAJOR MANDATORY COURSE - II (THEORY) [4 CREDITS]
BIOLOGY AND DIVERSITY OF PTERIDOPHYTES, GYMNOSPERMS AND PALAEOBOTANY
[TOTAL LECTURES: 60]

UNIT I: [15]

- ❖ Trends in classification system.
- ❖ Classification given by Pteridophytes Phylogeny Group – I (PPG – I)
- ❖ Morphology, anatomy, reproduction of following orders: Psilotales (*Tmesipteris* and *Psilotum*); Lycopodiales (*Lycopodium*, *Lycopodiella*); Isoetales (*Isoetes*); Selaginellales (*Selaginella*); Equisetales (*Equisetum*); Marattiales (*Angiopteris*); Polypodiales (*Pteris*, *Microsorium*); Salviniaceae (*Salvinia*).

UNIT II: [15]

- ❖ Classification of Gymnosperms by Christenhusz *et al.* (2011).
- ❖ Study of morphology, anatomy, reproductive organs and affinities of extant members of orders: Cycadales, Ginkgoales, Welwitschiales, Gnetales, Ephedrales, Pinales, Araucariales and Cupressales.

UNIT III: [15]

- ❖ Evolution in reproductive characters of Cycadales
- ❖ Economic importance of Pteridophytes and Gymnosperms
- ❖ Tissue culture and biotechnological aspects of Pteridophytes and Gymnosperms

UNIT IV: [15]

- ❖ Study of geological time scale.
- ❖ Techniques used in fossil studies.
- ❖ Morphology, anatomy and evolutionary trends of following extinct groups: Psilophytales, Sphenophyllales, Pteridospermales, Bennettitales, Cordaitales.

REFERENCE BOOKS:

- ❖ Andrews, H.N. 1961. *Studies in Paleobotany*.
- ❖ Arnold, C.A. 1972. *An introduction to paleobotany*.
- ❖ Bhatnagar, S.P. and Moitra A. 1996. *The Gymnosperms*.
- ❖ Bierhorst, D.W. 1971. *Morphology of vascular plants*.
- ❖ Bower, F. O. 1963. *The Ferns*.
- ❖ Chamberlain, C.J. 1966. *Gymnosperms, Structure and Evolution*.
- ❖ Coulter and Chamberlain, J. M. *Morphology of Gymnosperms*.
- ❖ Darroch, W.C. 1968. *Principles of Paleobotany*.
- ❖ Eames, A. J. and E. M. Giffard. 1950. *Comparative morphology of vascular plants*.
- ❖ Foster, A. S. and Gifford, E. M. 1959. *Comparative morphology of vascular plants*.
- ❖ Jermy, A. G. 1973. *The Phylogeny and Classification of ferns*.
- ❖ Parihar, N.S. 1959. *An Introduction to Pteridophyta*.
- ❖ Ramanujan, C.G.K. 1979. *Indian Gymnosperms in Time and Space*.

- ❖ Rashid, A. 1978. *An introduction to Pteridophytes*.
- ❖ Shukla, A.C. and Mishra, S.D. 1975. *Essentials of Paleobotany*.
- ❖ Spone, K.R. 1966. *Morphology of Pteridophytes*.
- ❖ Spone, K.R. 1967. *Morphology of Gymnosperms*.
- ❖ Stewart, W. N. 1983. *Paleobotany and the evolution of plants*. Cambridge U.S.
- ❖ Surange, K.R. 1968. *Indian Fossil Pteridophytes*.
- ❖ Trivedi, A. N. 2002. *Advances in Pteridology*.
- ❖ Vashishta, B.R. 1996. *Botany for degree students – Pteridophytes*.
- ❖ Vashishta, P.C. 1976. *The Gymnosperms*.

JOURNALS:

- ❖ American Fern Journal
- ❖ Indian Fern Journal
- ❖ Phytotaxa
- ❖ Taxon
- ❖ International Journal of plant sciences.

M. SC. PART-I (SEMESTER I)
MAJOR MANDATORY COURSE III (THEORY) [2 CREDITS]
TOOLS AND TECHNIQUES

[TOTAL LECTURES: 30]

Unit I: **[15]**

- ❖ **Microscopy:** Light microscope, Phase contrast microscope, Fluorescence microscope and Electron Microscopy: Transmission and Scanning.
- ❖ **Spectroscopic Techniques:** Introduction, principles and applications in UV-Vis, fluorescence, AAS, Infrared and Raman spectroscopy
- ❖ **Immunological techniques:** Immune response, Antibody and their specificity, Antigen, antibody interaction, Immuno- diffusion, Immuno- assay, Western Blotting.

UNIT II: **[15]**

- ❖ **Separation Techniques:** Centrifugation: Basic principles of centrifugation, types, rotors, care and safety aspects of centrifuge; preparative and analytical centrifugation; density gradient centrifugation.
- ❖ **Chromatographic Techniques:** Principles; Applications of Paper chromatography, TLC, Column chromatography, HPTLC, HPLC, GC, Affinity and ion exchange chromatography.
- ❖ **Electrophoretic Techniques:** Principle, support media, electrophoresis of proteins and nucleic acids, capillary and microchip electrophoresis, isoelectric focusing, staining, activity staining.

REFERENCE BOOKS:

- ❖ Practical cytology, applied genetics and Bio-statistics- Goswami H. K. and R. Goswami. Himalayan Publ. House, Bombay (1993)
- ❖ Methods in plant molecular biology – M. A. Schwer and Zeclinskin publ. Academic Press New York (1989)
- ❖ Photosynthesis and production in a changing environment. A field and laboratory manual- Hall, Scurlik, BolharNordenkampt, Leagood and Long Chapman and Hall Publ. (1993)
- ❖ Experimental plant physiology – J. Arditti and Dunn, Publ. Academic Press (1970).
- ❖ Techniques in Bioproductivity and photosynthesis by – Coombs, Hall, Long and Sourlock, Pergamon press Oxford (1985)
- ❖ Methods in enzymology- Colowick and Kaplan Academic Press.
- ❖ A Handbook of field and herbarium techniques- S. K. Jain and R. R. Rao (1977), New Delhi: Today and Tomorrow's Printers and Publishers, c1977
- ❖ Practical Biochemistry: Principles and Techniques. Ed. E. Wilson and J. Walker (2000) Cambridge Publ.
- ❖ Modern Experimental Biochemistry-Boyer, R. (2005). Pearsa, Education, Singapore.
- ❖ Methods in Experimental Biology. Ralph, R. (1975). Blakie, London
- ❖ An Introduction to Biometry- Mungikar, A. M. (1997), Saraswati Printing Press Aurangabad.
- ❖ Research Methodology for Biological Sciences (01 Edition, 2013). Gurumani, N. (2013). MJP Publishers.

- ❖ Botanical histochemistry: principles and practice- William A. Jensen (1962), W. H. Freeman, 1962 the University of Michigan.
- ❖ Flow Cytometry: First Principles (Second Edition)- Givan A.L. (2001), Wiley-Liss, Inc.
- ❖ Flow Cytometry Protocols (2nd edition), Methods in Molecular Biology (Volume 263)- Editors Hawley T.S. and Hawley R.G. (2004), Totowa, NJ: Humana Press
- ❖ Handbook of Histopathological and Histochemical Techniques (Including Museum Techniques) (Third Edition)- Culling C.F.A. (1974), Elsevier Ltd.
- ❖ Manual of Histological Techniques (1st Edition) - Mondal S.K. (2017)- Jaypee Brothers Medical Publishers.

M. SC. PART – I (SEMESTER - I)
MAJOR MANDATORY COURSE – IV (PRACTICAL) [2 CREDITS]

[10 PRACTICALS]

ALGAE (2 PRACTICALS)

- ❖ Study of Algal classes mentioned in theory paper (available specimens/slides): Cyanophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae, Rhodophyceae and Chrysophyceae

FUNGI (4 PRACTICALS)

- ❖ Detailed study of following types from each of the following orders (available specimens/slides): **Chytridiomycetes:** *Physoderma*, *Synchytrium*; **Zygomycetes:** *Glomus*; **Hemiascomycetes:** *Taprina*; **Pyrenomycetes:** *Claviceps*, *Xylaria*; **Discomycetes:** *Peziza*; **Teliomycetes:** *Melampsora*, *Uromyces*, *Ustilago*; **Hymenomycetes:** *Agaricus*, *Polyporus*; **Gasteromycetes:** *Cyathus*, *Phallus*; **Oomycetes:** *Saprolegnia*, *Plasmopara*, *Bremia*, *Albugo*; **Plasmodiophoromycetes:** *Plasmodiophora* (Slide); **Myxomycetes:** *Stemonitis*

BRYOPHYTES (2 PRACTICALS)

- ❖ Morphological, anatomical and reproductive studies of the following orders (available specimens/slides): **Marchantiopsida:** Marchantiales, Ricciales and Sphaerocarpaceae; **Jungermanniopsida:** Fossombroniales, Jungermanniales, and Metzgeriales; **Anthocerotopsida:** Anthocerotales, Notothyladales
- ❖ **Bryopsida:** Sphagnales, Funariales and Polytrichales; Preparation of identification key and herbarium techniques in Algae, fungi and bryophytes.

TOOLS AND TECHNIQUE (2 PRACTICALS)

- ❖ Separation of pigments/compounds by chromatographic techniques
- ❖ Verification of Beer and Lambert's law

M. SC. PART – I (SEMESTER – I)
MAJOR MANDATORY COURSE - V (PRACTICAL) [2 CREDITS]

[10 PRACTICALS]

PTERIDOPHYTES [4 PRACTICALS]

- ❖ Study of morphology, anatomy and reproductive organs of following members (available specimens/slides): *Psilotum*, *Lycopodium*, *Selaginella*, *Isoetes*, *Equisetum*, *Pteris*, *Angiopteris*, *Salvinia* and *Marsilea*.

GYMNOSPERMS [3 PRACTICALS]

- ❖ Study of the morphology and anatomy of the vegetative and reproductive parts of extant gymnosperms: *Araucaria*, *Juniperus*, *Podocarpus*, *Pinus*, *Cycas*, *Zamia* and *Ephedra* from available specimens/ slides.

PALAEOBOTANY [1 PRACTICAL]

- ❖ Study of following extinct specimens: *Sigillaria* Stem, *Sphenophyllum* Stem, *Pachytesta* Seed, *Elatocladus*, *Sahanianthus* flower.

TOOLS AND TECHNIQUE [2 PRACTICALS]

- ❖ Density gradient centrifugation
- ❖ Culture techniques

M. SC. PART – I (SEMESTER – I)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ANGIOSPERM TAXONOMY
THE EVOLUTION AND CLASSIFICATION OF ANGIOSPERMS

[TOTAL LECTURES: 30]

UNIT I: **[15]**

- ❖ **Principles and Practices in Plant Taxonomy:** Definitions and concepts, importance of taxonomy and need for classification, hierarchical classification, Alpha and Omega taxonomy, taxonomy as synthetic discipline.
- ❖ **The New Global Taxonomy Initiatives:** Systematic agenda - 2000, systematic knowledge and value of biodiversity, the missions of systematic agenda-2000. Biodiversity strategy and systematics Agenda for 2020.
- ❖ **Evolution of Flowering Plants:** Angiosperm apomorphies – Flower, Stamens, Reduced male gametophyte, Carpel, Two integuments, Reduced female gametophyte, Endosperm formation, Sieve tube members, Angiosperm specializations, Vessels. Origin of angiosperms.
- ❖ **Taxonomic Hierarchy:** Ranks of taxa, Forms of scientific names; major categories: division, class, order, family; minor categories: genus, species and intraspecific categories.

UNIT II: **[15]**

- ❖ **Brief History of Plant classifications:** Pre-Darwinian, Post Darwinian.
- ❖ **Recent Systems of Classifications:** Brief account of systems of classifications of Dahlgren, Takhtajan and Thorne
- ❖ **APG IV:** Basal angiosperms, Magnoliids, Monocots, Commelinids, Eudicots, Core Eudicots,
- ❖ Rosids, Fabids, Malvids, Asterids, Lamiids and Campanulids.
- ❖ **Morphological variations, systematic position, interrelationships, phylogeny and economic importance of following families:** ANITA GRADE (Hydatellaceae, Austrobaileyaceae), MAGNOLIIDS (Lauraceae, Piperaceae, Aristolochiaceae), MONOCOTS (Alismataceae, Hydrocharitaceae, Potamogetonaceae, Aponogetonaceae), COMMELINIDS (Commelinaceae, Typhaceae, Eriocaulaceae, Zingiberaceae, Costaceae, Musaceae).

M. SC. PART – I (SEMESTER – I)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
ANGIOSPERM TAXONOMY
THE EVOLUTION AND CLASSIFICATION OF ANGIOSPERMS

[10 PRACTICALS]

- ❖ Exercises on nomenclature problems.
- ❖ Describing new taxon.
- ❖ Study of flowers of primitive families: Magnoliaceae, Lauraceae, Aristolochiaceae,
- ❖ Piperaceae, Ranunculaceae, Alismataceae, Nymphaeaceae.
- ❖ Identification of wild and cultivated plant species using regional and national floras.
- ❖ Study of different types of ovules and placentations.
- ❖ Descriptions, sketching, classification and identification of families: ANITA GRADE- Hydatellaceae, MAGNOLIIDS- Lauraceae, Piperaceae, Aristolochiaceae; MONOCOTS- Alismataceae, Hydrocharitaceae, Potamogetonaceae, Aponogetonaceae; COMMELINIDS- Commelinaceae, Typhaceae, Eriocaulaceae, Zingiberaceae, Costaceae, Musaceae.
- ❖ Any additional practical/s based on theory syllabus will be added whenever necessary.

REFERENCE BOOKS:

- ❖ **Cronquist, A. 1981.** An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
- ❖ **Cronquist, A. 1988.** The Evolution and Classification of Flowering Plants (2nd ed.). Allen Press, U.S.A.
- ❖ **Davis, P. H. and V. H. Heywood 1991.** Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi.
- ❖ **Manilal, K. S. and M. S. Muktesh Kumar [eds.] 1998.** A Handbook of Taxonomic Training. DST, New Delhi.
- ❖ **Naik, V. N. 1984.** Taxonomy of Angiosperms. Tata McGraw-Hill, New Delhi.
- ❖ **Quicke, Donald L. J. 1993.** Principles and Techniques of Contemporary Taxonomy. Blakie Academic & Professional, London.
- ❖ **Taylor, D. V. and L. J. Hickey 1997.** Flowering Plants: Origin, Evolution and Phylogeny. CBS Publishers & Distributors, New Delhi.
- ❖ **Lawrence, G. H. M. 1951.** Taxonomy of Vascular Plants. Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
- ❖ **Takhtajan, A. 1969.** Flowering plants-Origin and Dispersal. Oliver and Boyd, Edinburgh.
- ❖ **Hutchinson, J. 1959.** Families of Flowering plants. Clarendon Press, Oxford.
- ❖ **Judd Walter S., Campbell, C. S., Kellogg, E. A., Stevens, P.F. and M. J. Donoghue. 2008.** Plant Systematics- A Phylogenetic Approach. Sinauer Associates, INC, Publishers. Sunderland, Massachusetts, USA.
- ❖ **Simpson, M. G. 2010.** Plant Systematics. Elsevier, Amsterdam.

M. SC. PART-I (SEMESTER I)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
CYTOGENETICS

[TOTAL LECTURES – 30]

UNIT I: **[15]**

- ❖ Introduction to cytogenetics. Mitotic and meiotic cell division
- ❖ **Meiosis:** modes of meiosis, Chromosome disjunction. Genetic control of meiosis, mechanism and theories of crossing over, Recombination models, Synaptonemal complex. Meiotic analysis in hybrids.
- ❖ *Drosophila* genetics: Life cycle, special type of chromosome, genetic regulation of development in *Drosophila*

UNIT II: **[15]**

- ❖ **Alien genetic resources in crop improvement:** Alien addition and substitution lines, hybrids between species with same chromosome number, alien translocation, hybrids between species with different chromosome number, gene transfer using amphidiploids, bridge species.
- ❖ **Apomixis:** types of apomixes in higher plants, evolutionary significance in plant breeding and genetic disadvantages.
- ❖ **Chromosome hybridization case studies:** production and use of haploids, dihaploids and double haploids in genetics and breeding.

M. SC. PART – I (SEMESTER – I)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
CYTOGENETICS

[10 PRACTICALS]

- ❖ Smear preparations in *Sorghum bicolor*, *Zea mays*, *Delphinium malabaricum*, *Solanum lycopersicum*, *Coix lachryma-jobi*, *Solanum sp.*
- ❖ Meiotic analysis in plants (Stages, chiasma, chiasma terminalization by using photographs, Pachytene analysis). Meiotic studies in structural hybrids (*Setcreatia sp.* *Cyanotis sp.*).
- ❖ Cytological analysis of polyploidy in plants and study of B chromosome in *Maize/Drimia*.
- ❖ Karyotype analysis.
- ❖ Study of life cycle in *Drosophila melanogaster* and special type of chromosomes in *Drosophila melanogaster*.
- ❖ Induction of polyploidy using colchicines.
- ❖ Chromosomal aberration studies in plants.
- ❖ Genome analysis in wheat, rice, cotton.
- ❖ Chromosome banding (C, Q, N, G)

REFERENCE BOOKS

- ❖ **Khush G. S.** 1973. Cytogenetics of aneuploides. Academic Press New York USA.
- ❖ **Burnham C. R.** 1962. Discussions in Cytogenetics. Burgess Publishing Co. Minnesota.
- ❖ **Harti D. L. and Jones E. W.** 1998. Genetics: Principles and Analysis 4th Edition. Jones and Barew Publishers Massachusetts USA.
- ❖ **Karp G.** 1999. Cell and Molecular Biology: Concepts and Experiments, John Wiley and Sons Inc USA.
- ❖ **Fikui K. and Nakayama S.** 1996. Plant chromosomes; Laboratory Methods CRC Press Boca Ration Florida.
- ❖ **Gupta P. K.** 1999. Cytogenetics. Rastogi Publication Meerut.
- ❖ **Prasad G.** 1998. Introduction to Cytogenetics. Kalyani Publishers, New Delhi.
- ❖ **Sinha U. and Sinha S.** 1998. Cytogenetics, Plant Breeding and Evolution. Vikas Publishing house Pvt. Ltd. New Delhi
- ❖ **Swaminathan M. S., Gupta P. K. and Sinha U.** 1974. Cytogenetics of Crop Plants MacMillan India Ltd. New Delhi.
- ❖ **Swanson C. P., Merz T. and Young J.** 1973. Cytogenetics. Prentice Hill of India Private Ltd. New Delhi.

M. SC. PART-I (SEMESTER I)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ENERGY, ECOLOGY AND ENVIRONMENT
ENVIRONMENT AND ITS ASPECT

[TOTAL LECTURES: 30]

UNIT I:

[15]

- ❖ **Soil Process:** Origin and formation of soil, Weathering process (Physical and chemical weathering Soil composition, Soil texture, Soil complex).
- ❖ **Soils:** Soil profile, Formation of humus.
- ❖ **Soil erosion:** Causes, Soil conservation methods, Soil types of India.
- ❖ **Land use classification,** integrated land use planning and water shade management, Waste land development, concept of soil map.

UNIT II:

[15]

- ❖ **Water:** Resources and Management. Surface and subsurface of water, Demand of Water (Agriculture, Domestic and Industrial), Hotspots of surface water, Role of state/ central commission in water resource management.
- ❖ **Abiotic Environment:** Liebig's Law of Minimum, Shelford's law of tolerance, Law of Limiting Factors.
- ❖ **Climate:** Classification of climate, structure of atmosphere, Edaphic factors, Climographs.
- ❖ **Environment in Terrestrial Ecosystems:** Classification of Biotic and Abiotic atmosphere, Interaction between organisms in an ecosystem. Light effects on plant life.

M. SC. PART – I (SEMESTER – I)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
ENERGY, ECOLOGY AND ENVIRONMENT
ENVIRONMENT AND ITS ASPECT

[10 PRACTICALS]

- ❖ Analysis of water samples from polluted and non-polluted lakes for DO.
- ❖ Determination of BOD at R.T.
- ❖ Study of wilting coefficient.
- ❖ Study of effect of effluents on plant growth.
- ❖ Field visits to Industrial area
- ❖ Determination of quality of water by physical parameters.
- ❖ Study of MPN as hydrobiological indicator.
- ❖ Study of soil profile.
- ❖ Determination of organic matter from soil.
- ❖ Ecological instruments used in air and water pollution studies.

REFERENCE BOOKS:

- ❖ **Agarwal, S. K.** (1992): Fundamentals of Ecology. New Delhi: Ashish Publishing House.

- ❖ **Bradbury, I. K.** (1990): The Biosphere. Published by John Wiley & Sons, Chichester.
- ❖ **Das, S. M.** (1989): Handbook of Limnology and water pollution with practical Methodology. Published by South Asian Publishers, New Delhi.
- ❖ **Etherington, J. R.** (1975): Environment and plant ecology: aims and development. Publisher Wiley.
- ❖ **Freedman, H. I.** (1980): Deterministic mathematical models in population ecology. Marcel Dekker Inc., New York.
- ❖ **Greig Smith, P.** (1983): Quantitative Plant Ecology. *Publisher:* WILEYBLACKWELL
- ❖ **Grims, J. P. et al** (1988): Comparative Plant Ecology. Colvend, Dalbeattie, Kirkcudrightshire [Scotland]: Castlepoint Press.
- ❖ **Hashimoto, Y. et al** (1990): Measurement techniques in plant sciences. San Diego, Calif.: Academic Press
- ❖ **Kershaw, K. A.** (1964): Quantitative and dynamic ecology. Publisher: Edward Arnold
- ❖ **Kormondy, E. J.** (1996): Concept of ecology. Publisher: Benjamin Cummings.
- ❖ **Krebs, C. J.** (1978): Ecology. Harper & Row., New York.
- ❖ **Lieth, H. F. et al** (1973): Patterns of primary production in the biosphere. Kluwer Academic Publishers-Plenum Publishers.
- ❖ **Misra, K. C.** (1989): Manual of plant ecology. Oxford and IBH Publishing Co., New Delhi.
- ❖ **Misra, R. and Das, R. R.** (1971): Proceedings of the school of plant ecology. Publisher: Calcutta Oxford & IBH Pub. Co.
- ❖ **Odum, E. P.** (1971): Ecology. Publisher: Saunders
- ❖ **Odum E. P.** (3rd ed. 1996): Fundamentals of Ecology. Natraj Publishers, Dehra Dun.
- ❖ **Pandeya S. C. et al** (1963): Research methods in plant ecology. Asia Publishing House.
- ❖ **Watt K. E. F.** (1973): Principles of Environment Sciences. Published by McGraw-Hill.
- ❖ **Sharma, P.D.** (2019): Ecology and Environment, Thirteenth edition. Rastogi publication.

M. SC. PART-I (SEMESTER I)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY
TAXONOMY OF FUNGI

[TOTAL LECTURE: 30]

UNIT I:

- ❖ General features of fungi.
- ❖ **Systems of classification of fungi:** Brief history of classification of fungi (Webster, 1980, Hawksworth *et al.* 1995) and recent phylogenetic classification of Fungi.
- ❖ **General characteristics of fungi:** Thallus organization, cell structure, pigment system composition nutrition and reproduction.
- ❖ **Micrometry:** Study of micrometry and its significance in fungal taxonomy.
- ❖ Types of culture media and their preparation, special culture media.

UNIT II

- ❖ Criteria used in the classification of fungi.
- ❖ **Morphology:** External and Internal, Vegetative and Reproductive, Cytological and Genetical, serological, nutritional, physiological, biochemical, host specificity and cultural.
- ❖ **Microtomy:** Types of microtomes, Techniques of microtomy, stains and fixatives used. Herbarium techniques for preservation of fungi.
- ❖ Status of taxonomical research of fungi in India.

M. SC. PART – I (SEMESTER – I)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY
TAXONOMY OF FUNGI

[10 PRACTICALS]

- ❖ Measurement of fungal dimensions by using micrometry.
- ❖ Identification of fungal genera using spore dimensions (e.g., Asterinales, Meliolales).
- ❖ Measurement of spore size and study of spore morphotypes, determination of standard deviation and frequency distribution, histogram and polygon. (In genera of Asterinales, Meliolales and Uredinales).
- ❖ Microtomy of fungal specimens. (e.g., Fleshy Ascomycetes member, rust fungi).
- ❖ Preparation of culture media: PDA, Czapek Dox Agar and Richard's medium.
- ❖ Isolation of fungi from air, soil, water, host, leaf litter and their identification.
- ❖ Types and techniques for preservation of fungi.

Reference Books:

- ❖ Ainsworth, G.E., Sparrow, F. K. and A. S. Sussman. 1973. The Fungi. Vol. I, II and III. Academic Press, New York.
- ❖ Alexopoulos, C.J., C.W. Mims and M. Blackwell. 1979. Introductory Mycology. A national book foundation, USA
- ❖ Aneja K.R. 1993: Experiments in Microbiology, Plant Pathology and Tissue New Age

international.

- ❖ Barnett, H.L. (1960): Illustrated genera of imperfect fungi. American Phytopathological Society, U.S.A.
- ❖ Bessey, E.A. (1967): Morphology and Taxonomy of fungi Blakiston Company, U.S.A.
- ❖ Buller, A.H.R. (1909-50): Researches on Fungi Vol. I-VIII. Longmans Green & Company, London, U. K.
- ❖ Gangopadhyay, S. (1994): Clinical Plant Pathology. Kalyani Publishers, Daryaganj, New Delhi.
- ❖ Gangulee, H. S. and A. K. Kar (1992): College Botany Vol. II. IV-A and IV-B. New Central Book Agency (P) Ltd., Kolkata. W. B. 16
- ❖ Johanson, D.A. (1940): Plant Microtechniques. McGraw-Hill Publishing Company Ltd., New York. U. S. A.
- ❖ Kendrick, W.B. (1979): Taxonomy of fungi imperfecti. Uni. Of Toronto Press, Canada
- ❖ Pandey, B.P. (1994): A Text Book of Botany: Fungi. International Publishing House, New Delhi.
- ❖ Rangaswamy G. (1975): Diseases of crop plants in India. PHI Learning Pvt. Ltd., M97 Cannaught Circle, New Delhi.
- ❖ Raychudhary, S. R. et al. (1975): Advances in Mycology and Plant Pathology.
- ❖ Sharma, O. P. (1989): Text Book of Fungi. Tata McGraw-Hill Education, 1989

Journals

- ❖ Annual Review of Plant Pathology.
- ❖ Canadian Journal of Botany.
- ❖ Mycologia.
- ❖ Indian Journal of Plant Pathology.

M. SC. PART-I (SEMESTER I)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
PLANT BIOTECHNOLOGY
PLANT TISSUE CULTURE

[TOTAL LECTURES: 30]

UNIT I: **[15]**

- ❖ Media preparation and handling, Sterilization technique, Equipment and apparatus, Procedure of media preparation and stock solution.
- ❖ Explant culture, Callus culture, Organogenesis, Meristem culture, Axillary bud culture, anther/ovary culture, embryo rescue.
- ❖ Hardening of tissue cultured plants.

UNIT II: **[15]**

- ❖ Cell suspension culture and its types, cell line isolation and significance.
- ❖ Somaclonal variations and significance.
- ❖ Protoplast isolation, culture and somatic hybridization.
- ❖ Synseed production and Cryopreservation: Procedure and importance.

M. SC. PART – I (SEMESTER – I)
MAJOR ELECTIVE PRACTICAL COURSE – II (PRACTICAL) [2 CREDITS]
PLANT BIOTECHNOLOGY
PLANT TISSUE CULTURE

[10 PRACTICALS]

- ❖ Media preparation and Sterilization techniques.
- ❖ Callus culture.
- ❖ Meristem culture.
- ❖ Encapsulation of somatic embryos and Synseed production.
- ❖ Technique of hardening.
- ❖ Anther culture.
- ❖ Cell suspension culture.
- ❖ Embryo culture.
- ❖ Visit to commercial greenhouse/ Tissue culture laboratory.
- ❖ Any other practical designed.

REFERENCES

- ❖ Bhojwani, S. S. and Razdan, M. K. 1983. Plant tissue culture, theory and practice. Elsevier Publ.
- ❖ Dixon, R. A. 1985. Plant cell culture- a practical approach. Oril Press Oxford.
- ❖ Doddas, J. H. and Roverts, L.W.1985. Experiments in plant tissue culture. Cambridge Uni. press.
- ❖ Evans et al. 1983. Hand book of plant cell culture vol. I, II, III. McMillan Publ. Co., New York.
- ❖ Gamborg, O. L. and Phillips, G. C.1966. Plant, tissue and organ culture- fundamental Methods. Narosa Publishing House, New Delhi.
- ❖ Narayanswamy, S. 1997. Plant cell and tissue culture. Tata McGraw Hill Publishers, New Delhi.

- ❖ Nelson, P. V. 1973. Greenhouse operation and management. Reston Publishing Co. Inc. Old, R. W. and Primerose, S. B. 2002. Principles of gene manipulation. Blackwell, Oxford, England.
- ❖ Raghavan, V. 1997. Molecular embryology of flower plants. Cambridge Uni. Press.
- ❖ Ravishankar, G. A. and Venkataraman, L. V. 1997. Biotechnological applications of plant tissue and cell culture. Oxford and IHB Publishing Co. Pvt. Ltd., New Delhi.
- ❖ Reddy, S. M., Srivastava, H. P., Purohit, D. K. and Reddy, S. R. 1997. Microbial biotechnology. Scientific Publishers, Jodhpur, India.
- ❖ Reinsert, J. and Bajaj, Y. P. S. 1976. Plant cell, tissue and organ culture. Springer Verlag, Berlin.
- ❖ Street, H. E. 1974. Tissue culture. Academic Press, New York.
- ❖ Thorpe, T. A. 1981. Plant tissue culture. Academic Press, New York

M. SC. PART-I (SEMESTER I)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
PLANT PHYSIOLOGY
ADVANCED PLANT PHYSIOLOGY AND PLANT BIOCHEMISTRY

[TOTAL LECTURES: 30]

UNIT I

[15]

- ❖ **Photosynthesis:** A brief outline of chlorophyll biosynthesis and the pigment organization in thylakoid membrane. Regulation of photosynthetic carbon reduction (PCR) Cycle and C4 Pathway; RUBISCO and PEPcase; C3 -C4 intermediates.
- ❖ **Respiration:** Glycolysis in plants and its regulation, Regulation of Pentose Phosphate Pathway and TCA Cycle, Regulation of electron transport chain and role of alternate oxidase.

UNIT II:

[15]

- ❖ **Carbohydrate metabolism:** Regulation of starch and sucrose biosynthesis, Synthesis and degradation of cellulose.
- ❖ **Secondary metabolites:** Shikimate Pathway and its role in biosynthesis of Secondary Metabolites.
- ❖ **Phosphorus nutrition:** Forms of phosphorus in soil. Phosphorus uptake, factors controlling 'P' uptake, 'P' fractions in plants. Role of Pyrophosphate in plant metabolism.

M. SC. PART – I (SEMESTER – I)
MAJOR ELECTIVE PRACTICALS COURSE – II (PRACTICAL) [2 CREDITS]
PLANT PHYSIOLOGY
ADVANCED PLANT PHYSIOLOGY AND PLANT BIOCHEMISTRY

[10 Practicals]

- ❖ To study the effect of potassium on glycolytic enzyme pyruvate kinase.
- ❖ Estimation of starch.
- ❖ Study of Oxalic acid accumulation in leaf tissue.
- ❖ Estimation of Ascorbic acid.
- ❖ Estimation of Polyphenols.
- ❖ Estimation of Cellulose.
- ❖ Study of Phosphorus distribution in different plant parts.
- ❖ Study of enzyme inorganic pyrophosphatase.
- ❖ Study of effect of light on chlorophyll biosynthesis.
- ❖ Study of enzyme polygalacturonase.

REFERENCE BOOKS

- ❖ Bidwell, R. C. S. (1979): Plant Physiology. Macmillan Bonner, J. and Varner, J.E. (1972): Plant Biochemistry. IBH.

- ❖ Edwards G. and Walker D., eds. (1983). C3, C4: mechanisms, and cellular and environmental regulation, of photosynthesis. Oxford: Blackwell Scientific Publications.
- ❖ Govindjee, H. (ed.) (1982): Photosynthesis, Vol. 1 and Vol. 2. Academic Press, N.Y. (Vol. 1); 0-12- 294302-2 (Vol. 2)
- ❖ Hopkins, W. C. (1995): Introduction to Plant Physiology. Wiley, New York.
- ❖ Krishnamurthy, H.N. (1992): Physiology of Plant Growth and Development. Atma Ram and Sons, Delhi.
- ❖ Marschner, H. W. (1986): Mineral nutrition of Higher Plants. First Edition, Academic Press, Elsevier Science Ltd.
- ❖ Marschner, H. W. (2003): Mineral nutrition of Higher Plants. Second Edition, Academic Press, Elsevier Science Ltd.
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- ❖ Mukherjee, S.P. and Ghosh A.N. (1996): Plant Physiology. New Central Book Agency (P) Limited Tata McGraw Hill.
- ❖ Noggle, G.R. and Fritz, G. J. (1976): Introductory Plant Physiology. Prentice- Hall, Inc., Englewood Cliffs, NJ.
- ❖ Pessarakli, M. (Ed.). (2001). Handbook of Plant and Crop Physiology, 2nd Edition, Revised and Expanded. Marcel Dekker, Inc., New York
- ❖ Pessarakli, M. (Ed.). (2005). Handbook of Photosynthesis, 2nd Edition, CRC Press, Taylor & Francis Publishing Company, Florida
- ❖ Randhir Singh and Sawhney S. K. (1988): Advances in frontier Areas of Plant Biochemistry. Prentice Hall of India
- ❖ Sadasivam S. and Manickam A. (1996): Biochemical methods. New Age International.
- ❖ Salisbury, F. B. and Ross, C. W. (1992): Plant Physiology IV ed. Cengage Learning
- ❖ Smith, H. (1975): Phytochrome and Photomorphogenesis. McGraw-Hill Inc.,US
- ❖ Taiz, L. and Zeiger, F. (1998): The Plant Physiology. Second Edition, Sunderland: Sinauer Associates.
- ❖ Wilkins, M. B. (1976): Physiology of Plant Growth and Development. McGraw-Hill Publishing Company Limited.

JOURNALS

- ❖ Annual Review of Plant Physiology and Molecular Biology
- ❖ Annual Review of Plant Physiology
- ❖ Indian Journal of Plant Physiology
- ❖ Journal of Experimental Botany

M. SC. PART I (SEMESTER I)
RESEARCH METHODOLOGY (THEORY) [4 CREDITS]

[TOTAL LECTURES: 60]

Unit I

[15]

- ❖ **Research:** Meaning, objectives, approaches and significance
- ❖ **Experimental design:** Basic principles, experimental error, replication, generalization and randomization, control.
- ❖ **Fundamentals of research:** Characteristics of research, classification of research (pure research, applied research, descriptive, experimental, historical etc.).

Unit II

[15]

- ❖ Types and sources of data; methods of data collection.
- ❖ Measures of central tendency (mean, mode, median) and dispersion (range, standard deviation, standard error, variance), probability, co-relation and regression.
- ❖ Binomial position and normal distribution, parametric and non-parametric tests, t-test, F-test, chi-square test, ANOVA.

Unit III

[15]

- ❖ Steps and elements of research process
- ❖ Preparation of research report, presentations, research proposals, research articles, review and book chapters.
- ❖ Research ethics, introduction to copyright, misconduct/plagiarism

Unit IV

[15]

- ❖ Biological databases and their applications
- ❖ Introduction to softwares (PAST, R, Excel, SPSS, Minitab and GeoCat)
- ❖ Journal matrices: citations, cite score, impact factor, h-index, i10 index, altmetrics.
- ❖ Legitimate and predatory journals.

M. SC. PART – I (SEMESTER II)
MAJOR MANDATORY COURSE – I (THEORY) [4 CREDITS]
ANGIOSPERM SYSTEMATICS

TOTAL LECTURES: [60]

UNIT I: **[15]**

- ❖ **Taxonomy:** Introduction, aims, principles and importance of taxonomy in charting, documentation, Bioprospecting, CBD implementation, conservation and sustainable use of plants.
- ❖ **Taxonomic Tools:** Herbarium, Botanical Gardens and their role in teaching, research and conservation; important herbaria and botanical gardens of the world and India, Important websites for taxonomic literature.
- ❖ **International Code of Nomenclature for Algae Fungi and Plants (ICN):** Brief history, Principles, Scientific names, Principle of priority, typification, valid and effective publication, *nomina conservanda*, *nomina rejicienda*.

UNIT II **[15]**

- ❖ **Evolutionary Concepts:** Key concepts in evolution- origin of intra-population variations, population and environment, general biological principle, transference of function, adaptive radiations, punctuated equilibrium.
- ❖ **Plant Speciation:** Morphological and biological species concept; allopatric, abrupt, sympatric, hybrid and apomictic speciation.
- ❖ **Reproductive Isolating Mechanisms:** Premating- temporal, habitat, floral, reproductive mode; post mating, prezygotic- incompatibility; post mating, postzygotic- incompatibility, hybrid inviability, hybrid floral isolation, hybrid sterility, hybrid breakdown.

UNIT III: **[15]**

- ❖ **Taxometrics:** Principles, Numerical taxonomy, methodology, merits and demerits
- ❖ **Cladistics:** Principles, cladistic approach in plant classification, methodology, merits and demerits.
- ❖ **Systems of Angiosperm Classification:** brief historical account of systems of classification, phylogenetic systems of angiosperm classification- Cronquist's systems of classification (up to subclass level), Angiosperm Phylogeny group, APG IV (2016) classification.

UNIT IV: **[15]**

- ❖ **Families of Angiosperms:** characteristic features, interrelationships, economic importance and classification as per APG-IV of the following groups and families: **ANA grade:** Amborellaceae, Nymphaeaceae, Hydatellaceae; **Magnoliids:** Magnoliaceae; **Monocots:** Araceae; **Commelinoids:** Arecaceae; **Eudicots:** Papaveraceae, **Core Eudicots:** Amaranthaceae; **Eurosids-I:** Malpighiaceae; **Eurosids-II:** Malvaceae, **Asterids:** Sapotaceae; **Euasterids-I:** Gentianaceae, Acanthaceae; **Euasterids-II:** Apiaceae, Asteraceae.

REFERENCES BOOKS:

- ❖ Briggs David 2009. Plant microevolution and Conservation in Human-influenced Ecosystems. Cambridge University Press.
- ❖ Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants Columbia University Press, New York.
- ❖ Cronquist, A. 1988. The Evolution and Classification of Flowering Plants (2nded.) Allen Press, U.S.A.
- ❖ Davis, P. H. and V. H. Heywood 1991. Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi.
- ❖ Hutchinson, J. 1959. Families of Flowering plants.
- ❖ Judd W. S., Campbell, C. S., Kellogg, E. A., Stevens P. F. and M. J. Donoghue 2008. Plant Systematics: A phylogenetic Approach. Sunderland, Massachusetts, USA.
- ❖ Lawrence George H. M. 1951. Taxonomy of Vascular Plants. Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
- ❖ Leadlay E. and S. Jury (ed.) 2006. Taxonomy and Plant conservation. Cambridge University Press.
- ❖ Manilal, K. S. and M. S. Muktesh Kumar [ed.] 1998. A Handbook of Taxonomic Training. DST, New Delhi.
- ❖ Naik, V. N. 1984. Taxonomy of Angiosperms. Tata McGraw-Hill Publication Com. Ltd. New Delhi
- ❖ Quicke, Donald, L. J. 1993. Principles and Techniques of Contemporary Taxonomy. Blakie Academic & Professional, London
- ❖ Simpson M. G. 2006. Plant systematics (Second Edition) Elsevier.
- ❖ Takhtajan, A. 1962. Flowering plants- Origin and Dispersal.
- ❖ Taylor, D. V. and L. J. Hickey 1997. Flowering Plants: Origin, Evolution and Phylogeny. CBS Publishers & Distributors, New Delhi.

M.SC. PART – I (SEMESTER – II)
MAJOR MANDATORY COURSE – II (THEORY) [4 CREDITS]
CELL AND MOLECULAR BIOLOGY

[TOTAL LECTURES: 60]

UNIT I: **[15]**

- ❖ **Dynamic cell:** General account of plant cell structure and its organization, cell organelles- their structure and functions.
- ❖ **Plasma membrane:** Structure, models and functions, sites for ATP ion carriers, channels and pumps, receptors, transport.
- ❖ **Plasmodesmata:** structure, role in movement of molecules.

UNIT II: **[15]**

- ❖ **Cell shape and motility:** The cytoskeleton, organization and role of microtubules and microfilaments, motor movements.
- ❖ **Cell division:** Mitosis and meiosis.
- ❖ **Cell cycle:** Cell cycle control system, cell cycle check points, Cyclin dependent kinases and cyclins.
- ❖ **Concept of gene,** DNA replication in Prokaryotes and Eukaryotes, Reverse transcription, DNA modification and repair.

UNIT III: **[15]**

- ❖ Cell signalling
- ❖ Signal transduction pathways, Secondary messengers, Regulation of signalling pathways.
- ❖ Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors.
- ❖ Two component system in Bacteria; Light signalling in plants.

UNIT IV **[15]**

- ❖ **Cellular communication:** General principles of cell communication, Cell adhesion and role of different adhesion molecules, Gap junctions, Extracellular matrix and integrins.
- ❖ **Cell apoptosis:** Intrinsic and Extrinsic pathways.

REFERENCE BOOKS:

- ❖ Johnson Lewys – 2004: *Cell Biology*; Sarup and Sons, New Delhi
- ❖ E.J. Dupraw – 1970: *Cell and Molecular Biology*; Academic Press, London
- ❖ De Robertis and De Robertis – 1997: *Cell and Molecular Biology (VIII)*
- ❖ C. P. Swanson, T. Merz, and W.J. Young – 1982: *Cytogenetics*
- ❖ P.C.L. John (Ed.) – 1981: *The cell cycle*; Cambridge University press
- ❖ Benjamin Lewin: *Genes – VI, VII and VIII*; Oxford Press.
- ❖ R. A. Chapoldi 1977: *Membrane proteins and their interactions with lipids*
- ❖ N. Mortonosi (Ed.) – 1985: *The enzymes of Biological Membranes Vol. I, II and III*
- ❖ Watson and others – 2004: *Molecular Biology of the gene (V)*
- ❖ P.C. Turner and others – 2002: *Molecular Biology (II)*

- ❖ W. Ream and K. G. Field – 1999: *Molecular Biology Techniques*
- ❖ Brace Albertsetal – 1983: *Molecular Biology of the cell*
- ❖ Charlothe J. Avers – 1986: *Molecular cell Biology*.
- ❖ Sandhya Mitra – 1988: *Elements of Molecular Biology*
- ❖ C. B. Powar – 1992: *Cell Biology*

JOURNALS:

- ❖ Annual review of plant Biology
- ❖ Cell
- ❖ Cytologia
- ❖ Journal of Genetics
- ❖ The Journal of cytology and Genetics
- ❖ Journal of Experimental Biology
- ❖ The journal of Biochemistry
- ❖ Indian journal of Biochemistry and Biophysics.
- ❖ Trends in Biotechnology

M. SC. PART – I (SEMESTER – II)
MAJOR MANDATORY COURSE – III (THEORY) [2 CREDITS]
STRUCTURE, DEVELOPMENT AND REPRODUCTION OF PLANTS
[TOTAL LECTURES: 60]

UNIT I: [15]

- ❖ Development of male and female gametophytes (sporogenesis and gametogenesis), and double fertilization in Angiosperm
- ❖ **Apomixis:** Types and significance
- ❖ **Polyembryony:** Classification and importance

UNIT II: [15]

- ❖ **Morphogenesis and organogenesis in plants:** Organization of shoot and root apical meristems; shoot and root development.
- ❖ **Palynotaxonomy:** Pollen morphology and plant taxonomy with suggested readings to Gymnosperms and Angiosperms.
- ❖ **Paleopalynology:** Principles, microfossil recovery theory and techniques, microfossil groups and oil exploration.
- ❖ **Aeropalynology:** Principles, techniques, pollen analysis, pollen and spore allergy, allergic properties of pollen, pollen calendar and importance.
- ❖ **Melittopalynology:** Bee colony, foraging behaviour of bees, unifloral and multifloral honey, application in crop productivity.

REFERENCE BOOKS

EMBRYOLOGY:

- ❖ Maheshwari, P. 1950: An introduction to the embryology of Angiosperm.
- ❖ Maheshwari, P. 1963: Recent advances on the embryology of Angiosperm.
- ❖ Johari, B M. 1963: Experimental embryology of vascular plants.
- ❖ Stanley, R G and F.L. Linkens 1974: Pollen biology, Biochemistry management
- ❖ Shivanna, K. R. and B M Johari 1989: The Angiosperm pollen, structure

ANATOMY:

- ❖ Barnova, M A. 1987: Historical developments of the present classification of morphological types of stomata. Bot.Res.53:53-79.
- ❖ Cutter, E G 1971 Plant Anatomy
- ❖ Dilcher, D D 1974: Approaches to the identification of angiosperms leaf remains.
- ❖ Emmes, E J. and M C Daniels, 1947: An introduction to plant anatomy.
- ❖ Easau, K. 1962: Plant anatomy –anatomy of seed plants.
- ❖ Fahn, A. 1969: Secretory Tissue system
- ❖ Foster, A S 1942: Practical plant anatomy
- ❖ Haberland, G. 1965: Physiological
- ❖ Masueth, J D. 1936: Plant anatomy
- ❖ Metcalfe, C R and L Chalk, 1950: Anatomy of the dicotyledons
- ❖ Solender, H. 1908: Systematics anatomy of the dicots
- ❖ Tomlinson, P S 1961: Anatomy of the monocotyledons.

PALYNOLOGY

- ❖ Cunningham, D D 1873: Microscopic examination of air.
- ❖ Fageri, K and J Inversen, 1964: Text book of pollen analysis.
- ❖ Nair, P K K 1964: Advances in Palynology.
- ❖ Nair, P K K 1966: Essentials of Palynology.
- ❖ Heslop-Harrison, Y. 1971: Pollen development and physiology.
- ❖ Gregory, P H, 1973: Microbiology of atmosphere.
- ❖ Erdtman, G. 1988: Pollen morphology and plant taxonomy.
- ❖ Tilak, S T. 1989: Airborne pollen and fungal spores.
- ❖ Shivanna K R and N S Rangaswami 1992: Pollen Biology, A Laboratory manual.
- ❖ Bhattacharya, K, M R Majumdar and S G Bhattacharya 2006: A Text book of Palynology.
- ❖ Shivanna K R and B M Johari, 1985: The Angiosperm Pollen, structure and function.
- ❖ Pandey and Chadha, 1992: Plant Anatomy and Embryology.

JOURNALS:

- ❖ Journal of Plant Sciences,
- ❖ Experimental Biology
- ❖ Developmental Biology
- ❖ Phytomorphology
- ❖ Currents sciences
- ❖ Plant Biology
- ❖ Int. Journal of Plant Sciences
- ❖ Pollen Biology and Fertilization
- ❖ Pollen Morphology
- ❖ Journal of Palaeontology

M. SC. PART – I (SEMESTER – II)
MAJOR MANDATORY COURSE – IV (PRACTICAL) [2 CREDITS]

[10 PRACTICALS]

ANGIOSPERM SYSTEMATICS [8 PRACTICALS]

- ❖ Study of general characteristic features, diagnostic characters, floral diagram, floral formula and classification of flowering plant families: Nymphaeaceae, Hydatellaceae, Magnoliaceae, Araceae, Arecaceae, Papaveraceae, Amaranthaceae, Malpighiaceae, Malvaceae, Sapotaceae, Gentianaceae, Acanthaceae, Apiaceae and Asteraceae as per APG-IV.
- ❖ Identification of genus and species (10 plants species) of locally available wild plants using regional and state floras.
- ❖ Preparation of dichotomous keys (indented and bracketed) for identification of taxa.
- ❖ Field trips within and around the University campus and compilation of report.

STRUCTURE, DEVELOPMENT AND REPRODUCTION OF PLANTS [2 PRACTICALS]

- ❖ Study of different types of stomata and trichomes
- ❖ Study of pollen morphotypes

M. SC. PART – I (SEMESTER – II)
MAJOR MANDATORY COURSE – V (PRACTICAL) [2 CREDITS]
[10 PRACTICALS]

CELL AND MOLECULAR BIOLOGY [8 PRACTICALS]

- ❖ Study of stages in cell cycle
- ❖ Preparation of feulgen stained chromosomes in root tip cells.
- ❖ Plant cell studies by fluorescent microscopy.
- ❖ Isolation, estimation and separation of DNA.
- ❖ Determination of melting temperature of DNA/Re-association Kinetics and estimation of Cot values.
- ❖ Isolation, estimation and separation of proteins.
- ❖ Study of enzyme activity: ATPase, Peroxidase and Catalase.

STRUCTURE, DEVELOPMENT AND REPRODUCTION OF PLANTS [2 PRACTICALS]

- ❖ Study of pollen viability.
- ❖ Study of living shoot apices of aquatic plants (*Ceratophyllum* & *Hydrilla*).
- ❖ Study of ultrastructure of male and female gametophytes.

M. SC. PART – I (SEMESTER - II)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ANGIOSPERM TAXONOMY
MODERN TRENDS IN ANGIOSPERM TAXONOMY

[TOTAL LECTURES: 30]

UNIT I: **[15]**

- ❖ **Embryology in relation to taxonomy:** Embryological characters of taxonomic importance, utilisation of embryological data in solving taxonomic problems at different levels.
- ❖ **Anatomy in relation to taxonomy:** Vegetative, wood and floral anatomy, anatomical characters of taxonomic importance, use of anatomical data in understanding interrelationship and evolution of angiosperms and solving taxonomic problems.
- ❖ **Palynotaxonomy:** Pollen morphology-Polarity, symmetry, NPC of pollen, exine stratification, excrescences, L/O pattern, palynogram; pollen characters of taxonomic importance.
- ❖ **Cytotaxonomy:** Chromosome number, Basic chromosome number, polyploidy, aneuploidy, chromosome morphology, karyotype, chromosome banding, meiotic analysis and plant systematics, scope and limitations.
- ❖ **Chemotaxonomy:** Origin of chemotaxonomy, classes of compounds and their biological significance, Stages in chemotaxonomic investigations, techniques, Use of chemical criteria in plant taxonomy; Proteins and taxonomy: seed proteins, techniques of protein electrophoresis, protein analysis procedures, analysis of amino acid sequence and its significance in systematics; serology and taxonomy: history, precipitation reaction, techniques, antigen, antisera, antibody, application of serological data in systematics

UNIT: II **[15]**

- ❖ **Ultrastructural systematics:** SEM and TEM studies and plant systematics; SEM and plant surface structure, TEM and dilated cisternae of endoplasmic reticulum and sieve element plastids, applications of data in the classification of higher taxa.
- ❖ **Molecular Systematics:** Molecular diagnostic tools, Restriction Fragment Length Polymorphism (RFLPs), Random Amplified Polymorphic DNA (RAPD), Polymerase Chain Reaction (PCR) analysis, specific applications of RAPD, AFLP in molecular systematics. Molecular data and systematic position of Hydatellaceae.
- ❖ **Morphological variations, systematic position, interrelationships, phylogeny and economic importance of following families:** EUDICOTS: Menispermaceae, Ranunculaceae, Nelumbonaceae CORE EUDICOTS: Nyctaginaceae, Portulacaceae, Polygonaceae, Loranthaceae, Santalaceae. ROSIDS: Vitaceae, Zygophyllaceae, Oxalidaceae, Euphorbiaceae, Rhizophoraceae, Passifloraceae, Polygalaceae.

M. SC. PART – I (SEMESTER – II)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
ANGIOSPERM TAXONOMY
MODERN TRENDS IN ANGIOSPERM TAXONOMY

[10 PRACTICALS]

- ❖ Microtome technique for study of embryological characters
- ❖ Study of wood characters: vessels, storied and nonstoried wood
- ❖ Semipermanent pollen preparations by acetolysis and study of different pollen morphotypes.
- ❖ Study of chromosomes and Karyotype analysis.
- ❖ Interpretation of flavonoids/alkaloids data for taxonomy using chromatography.
- ❖ Exercise on Numerical taxonomy
- ❖ Study of plant surface attributes with the help of SEM photographs and sieve tube plastid and dilated cisternae of endoplasmic reticulum with the help of TEM photographs
- ❖ Descriptions, Sketching, classification and identification of families: EUDICOTS: Menispermaceae, Ranunculaceae, Nelumbonaceae; CORE EUDICOTS: Nyctaginaceae, Portulacaceae, Polygonaceae, Loranthaceae, Santalaceae; ROSIDS: Vitaceae, Zygophyllaceae, Oxalidaceae, Euphorbiaceae, Rhizophoraceae, Passifloraceae, Polygalaceae.
- ❖ Any additional practical/s based on theory syllabus will be added whenever necessary.
- ❖ At least two local tours should be arranged to study vegetation, ecology and flowering of the region in first term. Student is supposed to submit herbarium specimens (50) and plant materials in the form of slides (5) and preserved specimens.)

REFERENCE BOOKS:

- ❖ **Bhojwani, S. S. and Bhatnagar, S. P. 1984.** Embryology of Angiosperms. Vikas Publ. House, New Dehli.
- ❖ **Cronquist, A. 1988.** The Evolution and Classification of Flowering Plants (2nd ed.) Allen Press, U.S.A.
- ❖ **Cronquist, A. 1981.** An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
- ❖ **Davis, P. H. and V. H. Heywood 1991.** Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi.
- ❖ **Erdtman, G. 1952.** Pollen Morphology and Plant Taxonomy. Angiosperms. Almquist and Wiksell. Stockholm.
- ❖ **Fahn, A. 1979.** Plant Anatomy, Pergamon Press, London.
- ❖ **Erdtman, G. 1952.** Pollen Morphology and Plant Taxonomy. Angiosperms. Hafner Publ. Co. New York.
- ❖ **Johri, B. M. 1984.** Comparative embryology of Angiosperms. Ind. Nat. Sc. Acad. New Delhi.
- ❖ **Maheshwari, P. 1985.** An Introduction to Embryology of Angiosperms. Tata McGraw Hill, New Delhi.

- ❖ **Manilal, K. S. and M. S. Muktesh Kumar [ed.] 1998.** A Handbook of Taxonomic Training. DST, New Delhi.
- ❖ **Naik, V. N. 1984.** Taxonomy of Angiosperms Tata McGraw-Hill, New Delhi.
- ❖ **Nair, P. K. K. 1966.** Pollen morphology of Angiosperms. Periodical Expert Book Agency, New Delhi.
- ❖ **Quicke, Donald, L. J. 1993.** Principles and Techniques of Contemporary Taxonomy. Blakie Academic & Professional, London.
- ❖ **Taylor, D. V. and L. J. Hickey 1997.** Flowering Plants: Origin, Evolution and Phylogeny. CBS Publishers & Distributors, New Delhi.
- ❖ **Lawrence, G. H. M. 1951.** Taxonomy of Vascular Plants. Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
- ❖ **Paech, K. and M. V. Tracey. 1956.** Modern Methods of Plant Analysis. Vol-I & II. Springer Verlag.
- ❖ **Shivanna, K. R. and N. S. Rangaswamy. 1992.** Pollen Biology- A Laboratory Manual. Springer Verla Sharma A. K. and A. Sharma. 1980. Chromosome Technique: Theory and Practices (3rd ed.) Butterworths, London.
- ❖ **Judd Walter S., Campbell, C. S., Kellogg, E. A., Stevens, P.F. and M. J. Donoghue 2008.** Plant Systematics-A Phylogenetic Approach Sinauer Associates, INC, Publishers. Sunderland, Massachusetts, USA.
- ❖ **Simpson, M. G. 2010.** Plant Systematics. Elsevier, Amsterdam.
- ❖ **Stace, C. A. 1989.** Plant Taxonomy and Biosystematics. Edward Arnold, London.

M. SC. PART – I (SEMESTER – II)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
PLANT BREEDING

[Total Lectures: 30]

UNIT I:

- ❖ Objectives of Plant Breeding, Domestication, Selection under domestication; Introduction,
- ❖ Quarantine; and Acclimatization of plants, Germplasm: Gene pool concept, Genetic erosion,
- ❖ Exploration and collection of germplasm, conservation and utilization, Mechanism of pollination control: self-incompatibility and male sterility, Concept of plant ideotype and its role in crop improvement.
- ❖ Inheritance of qualitative and quantitative characters, Biometrical techniques in plant breeding: Introduction, Assessment of variability, Components of variance, Genetic diversity, Heritability, estimation of variance components additive and dominance variances, combining ability GCA, SCA effects.

UNIT II:

- ❖ Aids to Selection: Correlation coefficient analysis, Path analysis and Discriminant functions.
- ❖ Choice of parents and breeding procedures: Diallele, Partial diallele, Triallele, Line X tester, Generation mean analysis, Biparental cross analysis with various designs and Varietal adaptation, Cultivar development: testing, release and notification maintenance. Plant breeders' right and regulations for plant variety protection and farmers right.
- ❖ Breeding for biotic and abiotic stresses: Disease and Salinity resistance.
- ❖ Mutation breeding

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
PLANT BREEDING

[10 PRACTICALS]

- ❖ Floral biology of self-pollinated and cross pollinated species
- ❖ Study of pollen germination and demonstration of incompatibility
- ❖ Metroglif and D² analysis
- ❖ To study crossability between cultivars
- ❖ Estimation of heritability
- ❖ Study of cytoplasm male sterility
- ❖ Designing field experiments
- ❖ Screening of germplasm for biotic and Abiotic stresses
- ❖ To study the effect of mutagen on germination, seedling growth and on mitosis
- ❖ To determine the Seed Germination by between paper (BP) method and estimation of Seed viability test using Tetrazolium test (TZ).

REFERENCE BOOKS:

- ❖ Allard R. W. 1960. Principles of Plant Breeding John Wiley and Sons, New York.
- ❖ Bulm A. 1988. Plant Breeding for stress Environments. CRC Press Florida.
- ❖ Chopra V. L. 1989. Plant Breeding. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- ❖ Fehr W. R. 1987. Principles of Cultivar Development (2 Volumes) MacMillan Publishing Co. New York.
- ❖ Hays H. K., Immer F.R. and Smith D.C. 1955. Methods of Plant Breeding. McGraw Hill Book Company Inc New York.
- ❖ Singh, B. D. 2000. Plant breeding- Principles and methods. Kalyani Publishers, Ludhiana.
- ❖ IAEA 1995. Induced mutations and Molecular techniques for crop improvement. Proc FAO/IAEA Symposium Vienna.
- ❖ IAEA 1991. Plant Mutation Breeding crop improvement Proc. FAO/IAEA Symposium (Vol 1&2) Vienna
- ❖ Levitt J. 1980. Response of Plants to Environmental Stress: Water, Salt and Other stresses. Academic Press, New York.
- ❖ Micke A. 1991. Induced Mutation for crop improvement. Gamma Field Symposia No.30 Institute of Radiation Breeding Pullman USA.
- ❖ Poehlman J.M. 1986. Breeding Field Crops AVI Publishing Company Connecticut. NEW YORK
- ❖ Rosielle A. A. and Hamblin J. 1981 Theoretical aspects of selection for yield in stress and nonstress environments Crop Sci, 21: 932-946.
- ❖ Roy Darbeshwar 2000, Plant breeding analysis and exploitation of variance. Narosa Publishers New Delhi.
- ❖ Sharma, J. R. 1994. Principles and practice of plant breeding. Tata McGraw Hill Publ. Co. Ltd., New Delhi.
- ❖ Siddiqui B. A. and Khna S. 1999. Breeding in crop plants. Mutation and *In vitro* mutation breeding. Kalyani Publishers New Delhi
- ❖ Sharma J. R. 1998. Statistical and Biometrical techniques in Plant Breeding New Age International Publishers New Delhi.
- ❖ Singh R. K. and Singh B. D. 1997. Biometrical Methods in Quantitative genetic Analysis. Kalyani Publishers, New Delhi.
- ❖ Vijendra Das L. D. 2000. Problems Facing Plant Breeding CBS Publishers New Delhi

JOURNALS:

- ❖ Indian Journal of Genetics and Plant Breeding.
- ❖ Journal of Genetics
- ❖ Caryologia
- ❖ Journal of Cytology and Genetics
- ❖ International Journal of Food Science and Technology
- ❖ Cytologia
- ❖ International Journal of Plant Breeding

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ENERGY, ECOLOGY AND ENVIRONMENT
POPULATION AND COMMUNITY ECOLOGY

[TOTAL LECTURES: 30]

UNIT I **[15]**

- ❖ **Population Ecology:** Population growth and regulation, Density dependent and Independent regulation: Role of different factors.
- ❖ **Genecology:** Ecads, Ecotypes, Characteristics of Ecotype, Origin of new ecotype and significance, concept of niche.
- ❖ **Functional Aspects of Community:** Community Periodism, Photoperiodism, Community Metabolism.

UNIT II **[15]**

- ❖ **Community Ecology:** Methods of Community studies.
- ❖ **Units of vegetation:** Classification of communities, Physiognomic classification, Phytosociological classification.
- ❖ **Clementsian unit of vegetation:** Plant formation, Associations, Faciation, Lociation, Consociation, Society, Aspects of society, Main concepts.
- ❖ **Community Nature:** Individualistic and organismic nature of communities, community stratification.
- ❖ **Forest Ecology:** Scope and relevance, Forest types of India, Structure of forest ecosystem Accumulation and decomposition of forest litter, Forest humus.

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – II (PRACTICALS) [2 CREDITS]
PLANT ECOLOGY AND EVOLUTION
POPULATION AND COMMUNITY ECOLOGY

[10 PRACTICALS]

- ❖ Study of litter production.
- ❖ Determination of similarity index and association index.
- ❖ Study of stratification and physiognomy.
- ❖ Determination of IVI.
- ❖ Study of population growth curve.
- ❖ Study of vegetation by transects method.
- ❖ Measurement of biomass production.
- ❖ Biomass profile of the plant community.
- ❖ Study of population dynamics
- ❖ Visit to local protected or conserved area.

REFERENCE BOOKS

- ❖ **Abe, T., Levin, S. A. and Higashi, M.** (1997) (ed.): Biodiversity an Ecological Perspective. Springer Verlag.
- ❖ **Bradbury I.K.** (1990): The Biosphere.

- ❖ **Brij Gopal and Bhardwaj, N.** (1979): Elements of Ecology. Sahibabad: Vikas Publishing House PVT. Ltd.
- ❖ **Galston, K. J.** (1996): Biodiversity: A biology of numbers and differences. Kluwer Academic *Publishers*, Dordrecht, the Netherlands.
- ❖ **Greig Smith P.** (1983): Quantitative Plant Ecology. *Publisher*: WILEYBLACKWELL
- ❖ **Hamson, H. C. and Churchill, E. D.** (1961): The Plant Community. Reinhold *publishing* corporation, New York.
- ❖ **Hashimoto Y et al.,** (1990): Measurement techniques in plant sciences. San Diego, Calif.: Academic Press.
- ❖ **Kormondy E. J.** (1996) (4th ed.): Concept of ecology. Publisher: Benjamin Cummings.
- ❖ **Krattiger, A. I. et al** (1994): Widening Perspectives on Biodiversity. Kluwer Academic *Publishers*.
- ❖ **Krebs C. J.** (1978): Ecology. Harper & Row., New York.
- ❖ **Misra K. C.** (1989): Manual of plant ecology. Oxford and IBH Publishing Co., New Delhi.
- ❖ **Nair, P. K. G.** (1990): Principles of Environmental Biology. Himalaya *Publishing* House (Bombay).
- ❖ **Odum E. P.** (3rd ed. 1996): Fundamentals of Ecology. Natraj Publishers, Dehra Dun.
- ❖ **Pandeya S. C., Puri, G. S. and Singh, J. S.** (1968): Research methods in plant ecology. Asia Publishing House.
- ❖ **Sharma, P.D.** (2019): Ecology and Environment, Thirteenth edition. Rastogi publication
- ❖ **Rana, S.V.S.** (2003): Essentials of Ecology and Environmental Science. Prentice Hall of India, New Delhi.
- ❖ **Shukla, R. S. and Chandel, P. S.** (1983): Plant Ecology. Oxford and IBH *publishers*, New Delhi, India.
- ❖ **Walter, H.** (1979); Vegetation of the Earth and Ecological Systems of Geobiosphere. Springer, New York.
- ❖ **Weaver, J. E. and Clements, F. S.** (1938): Plant Ecology. Springer, New York.
- ❖ **Willis, A. J.** (1973): Introduction to Plant Ecology. *Willis A J. Publisher*.

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY
INTEGRATED DISEASE MANAGEMENT

[TOTAL LECTURES: 30]

UNIT I

[15]

- ❖ **Principles of plant pathology:** History of plant Pathology, Classification of crop diseases based on symptoms and Deficiency of micronutrients.
- ❖ **Seed pathology:** Methods of detection of internal and external seed borne Fungi, Bacteria and Viruses.
- ❖ **Methods of disease diagnosis:** field observation, isolation and identification of pathogens.
- ❖ Biodeterioration of seeds and mycotoxins.

UNIT II

[15]

- ❖ Integrated management of plant diseases.
- ❖ Definition of disease management, international approach, quarantine laws, cultural practices for avoidance of pathogen, breeding and use of disease resistant varieties, seed certification
- ❖ **Chemical methods:** Classification of fungicides (Contact and systemic fungicides) and seed and soil treatment with fungicide, antibiotics, biological control of plant pathogens and biological control agents (*Mycorrhiza*, *Trichoderma*, sp., *Pseudomonas fluorescens*, *Glomus* spp.); Biopesticides.
- ❖ **Integrated management of some fungal diseases:** History, Symptomology, pathogen, etiology and management of Jowar (Head and grain smut), Bajara (Green ear disease), Wheat (Rust), Rice (Blast), Groundnut (Leaf spot), Soybean (mosaic) and cotton (Angular leaf spot) diseases.

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY
INTEGRATED DISEASE MANAGEMENT

[10 PRACTICALS]

- ❖ Isolation techniques for fungi
- ❖ Study of micronutrient deficiency symptoms in crops
- ❖ Methods for detection of externally seed borne pathogens by blotter and agar plate method; their identification and classification.
- ❖ Method of detection of internally seed borne pathogen by direct plating.
- ❖ Quantitative estimation of aflatoxins from infected seeds using Thin Layer Chromatography
- ❖ Determination of antagonistic effect of *Trichoderma* against plant pathogen

Reference Books:

- ❖ Agrios, G. N. (2006). Plant Pathology (5th Edition). Academy Press, London.

- ❖ Aneja, K. R. (1993). Experiments in Microbiology, Plant Pathology and Tissue Culture. New Age international.
- ❖ Cooke, A. A. (1981). Diseases of Tropical and Subtropical Field, fiber and Oilplants.
- ❖ Gangopadhyay, S. (1994). Clinical Plant Pathology. Kalyani Publishers, Daryaganj, New Delhi.
- ❖ Gangulee, H. S. and Kar, A. K. (1992). College Botany Vol. II. New Central Book Agency (P) Ltd., Kolkata. W. B.
- ❖ Jha, D. K. (1993). A text book on Seed Pathology. Vikas Publishing House Pvt. Ltd., 576 Masjid Road, Jangpura, New Delhi-110014.
- ❖ Kuljit, J. (1969). The Biology of parasitic flowering plants. Uni. Of California Press, U. S. A.
- ❖ Mahadevan, A. and Shridhar, R. (1982). Methods in Physiological Plant. PHI Learning Pvt. Ltd., M97 Cannaught Circle, New Delhi.
- ❖ Mehrotra, R. S. (1980). Plant Pathology. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
- ❖ Nair, L. N. (2007). Topics in Mycology and Plant Pathology. New Central Book Agency (P) Ltd., Kolkata. W. B.
- ❖ Neergard, P. (1977). Seed Pathology. Vol. I & II, Macmillan Press, London.
- ❖ Nyvall, R. F. (1979). Field Crop Diseases Handbook.
- ❖ Padoley, S. K. and Mistry, P. B. A manual of plant Pathology.
- ❖ Paul Khurana, S. M. (1998). Pathological problems of Economic Crop Plants and their Management.
- ❖ Plank, J. E. Vander (1968). Plant Diseases, Epidemics and Control. Academy Press, London.
- ❖ Rangaswamy, G. (1975): Diseases of crop plants in India. Diseases of crop Plants in India. PHI
- ❖ Learning Pvt. Ltd., M97 Cannaught Circle, New Delhi.
- ❖ Singh, R. S. (1963): Plant Diseases. Oxford and IBH Publishing

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
PLANT BIOTECHNOLOGY
MOLECULAR BIOTECHNOLOGY AND GENETIC ENGINEERING
[TOTAL LECTURES: 30]

UNIT I **[15]**

- ❖ Restriction endonucleases and their importance in gene cloning, Enzymes used in recombinant DNA technology: DNA polymerase, ligase and DNA modifying enzymes (methylases, alkaline phosphatases, topoisomerases).
- ❖ Cloning vectors (Plasmids, Phagemids, Cosmids, Viral vectors, Shuttle vectors & Binary vectors).
- ❖ Expression vectors: Bacterial, yeast, animal and plant.
- ❖ Molecular research procedure; Gene amplification, basic PCR, its modification, application, DNA polymorphism.

UNIT II **[15]**

- ❖ Blotting techniques: Southern, Northern and Western blotting.
- ❖ Molecular markers: RFLP, RAPD, AFLP, SSR and their applications.
- ❖ DNA fingerprinting technology and its application in forensic science.
- ❖ PCR technology: Synthesis of oligonucleotide primers, PCR amplification of specific DNA sequences, Cloning PCR products, thermostable DNA polymerases and applications of PCR technology in Biology and Medicine

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
PLANT BIOTECHNOLOGY
MOLECULAR BIOTECHNOLOGY AND GENETIC ENGINEERING
[10 PRACTICALS]

- ❖ Isolation of plant genomic DNA.
- ❖ Estimation and comparison of genomic DNA by UV-vis spectrophotometry.
- ❖ Preparation of electro and chemically competent *E. coli*.
- ❖ Restriction digestion of DNA.
- ❖ Two- dimensional (2-D) paper chromatography of amino acids.
- ❖ Demonstration of gene assay (GUS/ CAT/ β -GAL).
- ❖ DNA electrophoresis.
- ❖ Any other relevant practical designed.

REFERENCE BOOKS

- ❖ Chavala, H. S. 1998. Biotechnology in crop improvement. International Book Distributing Co. New Delhi.
- ❖ Glick, B. R. and Pasternak, J. J. 1994. Molecular Biotechnology- Principles and applications of recombinant DNA. ASM Press, Washington.
- ❖ Gupta, P. K. 2000. Elements of Biotechnology. Rastogi Publisher, Meerut, India.
- ❖ Jogdand, S. N. 1997. Gene Biotechnology, Himalaya Publishing House, Mumbai, India.
- ❖ Joshi, P. 1998. Genetic Engineering and its applications. Agrobotanica.
- ❖ Kakralya, B. and Ahuja, I. 2001. Transgenic Plants-Promise or Danger. Agrobios, India.
- ❖ Mitra, S. 1996. Genetic Engineering- principles and practice. Mcmilan, India ltd.

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
PLANT PHYSIOLOGY
PLANT GROWTH AND DEVELOPMENT

[TOTAL LECTURES 30]

UNIT I:

- ❖ **Growth and morphogenesis:** Photomorphogenesis; Phytochromes, cryptochromes and their photochemical and biochemical properties, phytochrome biosynthesis, cellular localization, roles, mechanism of action of photo morphogenetic receptors.
- ❖ **Pollen germination:** Physiology of pollen germination and pollen-pistil interaction.
- ❖ **Senescence and PCD:** Biochemical changes during senescence of leaves and petals. Regulation of senescence, Programmed Cell Death.

UNIT II:

- ❖ **Post-harvest physiology:** Ripening of fruit and its regulation. Metabolism of leafy vegetables during storage. Role of biotechnology and mutants in physiological studies.
- ❖ **Plant growth regulators:** Discovery, role and possible mechanism of action of Triacantanol, Brassins, Salicylic acid, Jasmonates and Polyamines. Role of plant growth retardants, chlorocholine chloride (CCC).

M. SC. PART-I (SEMESTER II)
MAJOR ELECTIVE COURSE – II (PRACTICALS) [2 CREDITS]
PLANT PHYSIOLOGY
PLANT GROWTH AND DEVELOPMENT

[10 PRACTICALS]

- ❖ Hormonal regulation of leaf and petal senescence.
- ❖ Study of changes in RNA and Proteins during senescence.
- ❖ Effect of chlorocholine chloride on seedling growth.
- ❖ Study of enzyme pectinase/pectin methyl esterase during ripening of fruit.
- ❖ Study of changes in respiration rate during ripening of fruits.
- ❖ Study of lipid accumulation during development of oil seeds.
- ❖ Effect of chemical compounds on pollen germination.
- ❖ Study of effect of different PGRs on seedling growth and vigour.

REFERENCE BOOKS

- ❖ **Bidwell, R. C. S. (1979):** Plant Physiology. Macmillan Bonner, J. and Varner, J.E. (1972): Plant Biochemistry. IBH.
- ❖ **Edwards G. and Walker D., eds. (1983).** C3, C4: mechanisms, and cellular and environmental regulation, of photosynthesis. Oxford: Blackwell Scientific Publications.
- ❖ **Govindjee, H. (ed.) (1982):** Photosynthesis, Vol. 1 and Vol. 2. Academic Press, N.Y. (Vol. 1); 0- 12- 294302-2 (Vol. 2))
- ❖ **Hopkins, W. C. (1995):** Introduction to Plant Physiology. Wiley, New York.

- ❖ **Krishnamurthy, H.N. (1992):** Physiology of Plant Growth and Development. Atma Ram and Sons, Delhi.
- ❖ **Marschner, H. W. (1986):** Mineral nutrition of Higher Plants. First Edition, Academic Press, Elsevier Science Ltd.
- ❖ **Marschner, H. W. (2003):** Mineral nutrition of Higher Plants. Second Edition, Academic Press, Elsevier Science Ltd.
- ❖ **Moore, T.C. (1974):** Research experience in Plant Physiology, A Laboratory manual. SpringerVerlag, Berlin.
- ❖ **Mukherjee, S.P. and Ghosh A.N. (1996):** Plant Physiology. New Central Book Agency (P) Limited Tata McGraw Hill.
- ❖ **Noggle, G.R. and Fritz, G. J. (1976):** Introductory Plant Physiology. Prentice- Hall, Inc., Englewood Cliffs, NJ.
- ❖ **Pessarakli, M. (Ed.). (2001).** Handbook of Plant and Crop Physiology, 2nd Edition, Revised and Expanded. Marcel Dekker, Inc., New York
- ❖ **Pessarakli, M. (Ed.). (2005).** Handbook of Photosynthesis, 2nd Edition, CRC Press, Taylor & Francis Publishing Company, Florida
- ❖ **Randhir Singh and Sawhney S. K. (1988):** Advances in frontier Areas of Plant Biochemistry. Prentice Hall of India
- ❖ **Sadasivam S. and Manickam A. (1996):** Biochemical methods. New Age International.
- ❖ **Salisbury, F. B. and Ross, C.W.(1992):** Plant Physiology IV ed. Cengage Learning
- ❖ **Smith, H. (1975):** Phytochrome and Photomorphogenesis. McGraw-Hill Inc.,US
- ❖ **Taiz, L. and Zeiger, F. (1998):** The Plant Physiology. Second Edition, Sunderland: Sinauer Associates.
- ❖ **Wilkins, M. B. (1976):** Physiology of Plant Growth and Development. McGraw-Hill Publishing Company Limited

M.SC. PART-I (SEMESTER II)
ON JOB TRAINING (OJT)/ FIELD PROJECTS (FP) [4 CREDITS]

M. SC. PART – II (SEMESTER III)
MAJOR MANDATORY COURSE –I (THEORY)
CYTOGENETICS AND CROP IMPROVEMENT

[TOTAL LECTURES: 60]

UNIT I: **[15]**

- ❖ **Cytology:** Chromatin organization, Chromosome structure and packaging of DNA, Molecular organization of centromere and telomere, Nucleolus and ribosomal RNA genes, Euchromatin and heterochromatin, Karyotype analysis and evolution, Banding patterns. Chromosome tracking/introgression using FISH and GISH, localization and mapping of genes or genomic segments.

UNIT II: **[15]**

- ❖ **Genetics of Prokaryotes and Eukaryotes:** Mapping of prokaryotic and eukaryotic genome, Mobile genetic elements and their significance, Gene families. Process of crop evolution and stabilization of polyploids (cytogenetic and genetic stabilization).
- ❖ **Crop Genetic Resources:** Centres of origin of cultivated plants, 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.

UNIT III: **[15]**

- ❖ **Population and Evolutionary Genetics:** Evolutionary theory and population genetics, Theory of allele frequencies, Changes in genetic structure of population: Natural selection, Migration, Mutation, Genetic drift. Genetic variation in natural populations. Gene flow and population structure.

UNIT IV: **[15]**

- ❖ **Classical and modern methods of crop breeding and improvement:** Genetic variability in crop plants, Methods of breeding in self and cross pollinated crops, Heterosis and hybrid development. Use of cytoplasmic male sterility in hybrid breeding, breeding methods in asexual and clonally propagated crops, clonal selection, Marker assisted breeding.

REFERENCE BOOKS:

- ❖ **Bahekar V. S. 1993.** Problems in Genetics Vol. I Arati Prakashan, Aurangabad.
- ❖ **Chahal G. S. and Gosal S. S. 2003.** Principles and Procedures of Plant Breeding biotechnological and conventional approaches. Narosa Publishers, New Delhi.
- ❖ **Darnel, J., Lodish, H. and Baltimore, D. 1990.** Molecular cell biology. Scientific American Books.
- ❖ **Gardner, E. J. 1991.** Principles of Genetics. John Wiley and sons, New York.
- ❖ **Jahier, J. 1996** Techniques of plant Cytogenetics. Oxford and IBH Publishing.
- ❖ **Lewin, B. 2008** Genes IX. Oxford University Press,
- ❖ **Mandal, A. K., Ganguli, P. K. and Banarjee, S. P. 1991** Advances in plant breeding Vol. I & II. CBS Publishers & Distributors.
- ❖ **Mayo, O. 1980.** The theory of Plant Breeding. Clarendon Press, Oxford.

- ❖ Mitra Sandhya 1994 Genetics a blueprint of life. Tata McGraw- Hill Publishing Company Ltd, New Delhi.
- ❖ Roy Darbeshwar 2000, Plant breeding analysis and exploitation of variance. Narosa Publishers, New Delhi.
- ❖ Russell P. J. 1998. Genetics (Fifth edition) Benjamin / Cummings Publishing Company Canada.
- ❖ Sharma J. R. 1998 Statistical and Biometrical techniques in Plant Breeding New Age International Publishers, New Delhi.
- ❖ Sharma, A. K. and Sharma, A. 1980. Chromosome techniques- Theory and practice. Butterworth and Co. (Publishers) Ltd., London.
- ❖ Sharma, J. R. 1994 Principles and practice of plant breeding. Tata McGraw Hill Publ. Co. Ltd., New Delhi.
- ❖ Singh, B. D. 2000. Plant breeding- Principles and methods. Kalyani Publishers, Ludhiana.
- ❖ Snustad D. P. and Simmons M. J. 2003, Principles of Genetics, (Third edition) John Wiley and Sons Inc.
- ❖ Strickberger, M. W. 1968. Genetics. The Macmillan Company, New York.
- ❖ Swaminathan, M. S., Gupta, P. K. and Sinha, U. 1983. Cytogenetics of crop plants. Macmillan India Ltd., Delhi.
- ❖ Swanson, C. P. 1968. Cytology and Cytogenetics. Macmillan and Co. Ltd., London.
- ❖ Sybenga, J. 1975. Meiotic configurations. Springer Verlag, Berlin, Germany.
- ❖ Winkler, U. Ruger W. and Wackernagel W. 1979. Bacterial, phage and molecular genetics. Narosa Publication, New Delhi.

JOURNALS:

- ❖ Indian Journal of Genetics and Plant Breeding.
- ❖ Journal of Genetics. Journal of Cytology and
- ❖ Genetics. Cytologia.
- ❖ Caryologia.
- ❖ International Journal of Food Science and Technology.
- ❖ Plant Breeding.
- ❖ Theoretical and Applied Genetics.

M.SC. PART – II (SEMESTER III)
MAJOR MANDATORY COURSE II (THEORY)
BIOTECHNOLOGY AND GENETIC ENGINEERING

[TOTAL LECTURES: 60]

UNIT I: [15]

- ❖ Concept, principle and application of recombinant DNA technology
- ❖ Enzymes used in recombinant DNA technology, Restriction mapping, Cloning vectors, Construction of chimeric DNA.
- ❖ Construction of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors.

UNIT II: [15]

- ❖ *In vitro* mutagenesis, deletion techniques and RNA interference.
- ❖ Gene knock-out in bacterial and eukaryotic organisms and CRISPER cas9.
- ❖ DNA sequencing methods, strategies for genome sequencing.
- ❖ RFLP, RAPD, SSR and AFLP techniques.

UNIT III: [15]

- ❖ Process and Techniques in plant transformation, Binary vectors for plant transformation
- ❖ Strategies for engineering plants for biotic and abiotic stress resistance.
- ❖ Transgenics for nutritional quality improvement in plants.
- ❖ Methods for analysis of gene expression at RNA and protein level, large scale expression, micro-array based techniques.

UNIT IV: [15]

- ❖ Screening of transgenics using blotting techniques: Southern, Northern and Western.
- ❖ Intellectual property rights (IPR) and protection (IPP): Concept, importance, ecological risks, ethical concerns and economic concerns.
- ❖ Genomics: *Arabidopsis* genome, Comparative genomics, Functional genomics
- ❖ Proteomics: Rationale, basic assumptions, methods for protein engineering

REFERENCE BOOKS:

- ❖ **Gupta, P. K.** 2010. Plant Biotechnology. Rastogi Publications, Meerut.
- ❖ **Glick, B. R. and Pasternak, J. J.** 1994. Molecular Biotechnology- Principles and Applications of Recombinant DNA. ASM Press, Washington D. C.
- ❖ **Gupta, P. K.** 2009. Biotechnology and Genomics. Rastogi Publications, Meerut.
- ❖ **Trehan, K.** 1994. Biotechnology. Wiley Eastern Limited, New Delhi.
- ❖ **Ramawat, K. G.** 2006. Plant Biotechnology. S. Chand and Company Ltd., New Delhi.
- ❖ **Trivedi, P. C.** (ed.) 2000. Plant Biotechnology- Recent Advances. Panima Publishing Corporation, New Delhi.
- ❖ **Chawla, H. S.** 1998. Biotechnology in Crop Improvement. International Book Distributing Company, Lucknow.
- ❖ **Aneja, K. P.** 1996. Experiments in Microbiology, Plant pathology, Tissue culture and Mushroom cultivation. Weshwa Prakashan, New Delhi.

- ❖ **Sullia, S. B. and Shantharam, S.** 2005. General Microbiology. Oxford & IBH Publ. Ltd., New Delhi.
- ❖ **Tauro, P.; Kapoor, K. K. and Yadav, K. S.** 1996. An Introduction to Microbiology. Wiley Eastern Limited, New Delhi.
- ❖ **Razdan, M. K.** 1994: An Introduction to plant tissue culture. Oxford & IBH Publ. Ltd., New Delhi.
- ❖ **Kumar, H. D.** 1993. Molecular Biology and Biotechnology, Vikas Publ., New Delhi.
- ❖ **Gamborg, O. L., Phillips, G. C.** 1995. Plant Cell, Tissue and Organ Culture-Fundamental Methods. Narosa Publ. House, New Delhi.
- ❖ **Reinhert, J. and Bajaj, Y. P. S.** 1977. Applied and fundamental aspects of plant cell, tissue and organ culture, Springer Verlag, Berlin.
- ❖ **Dodds, J. H. and Roberts, L. W.** 1985. Experiments in plant tissue culture. Cambridge University Press, Cambridge.
- ❖ **Boyce, C.O.L.** 1986. Novo's Handbook of Practical Biotechnology. Novo Industry.

M.SC. PART – II (SEMESTER III)
MAJOR MANDATORY COURSE III [2 CREDITS]
PLANT ECOLOGY AND EVOLUTION

[TOTAL LECTURES: 30]

UNIT-I: [15]

- ❖ **Origin of cells and unicellular evolution:** Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparane and Haldane; Experiment of Miller (1953).
- ❖ **Emergence of evolutionary thoughts:** Lamarck; Darwin-concepts of variation, adaptation, struggle, fitness and natural selection; Spontaneity of mutations; the evolutionary synthesis.
- ❖ **Ecological Succession:** Types; mechanisms; changes involved in succession, concept of climax.

Unit-II: [15]

- ❖ **Population Ecology:** Characteristics of a population; population growth curves; population regulation, life history strategies (r and K selection); concept of metapopulation - demes and dispersal, interdemic extinctions, age structured populations.
- ❖ **Terrestrial biomes** – Grassland, tropical rainforest, temperate deciduous forest.
- ❖ **Aquatic biomes** – Fresh water ecosystem – Lotic and Lentic; Marine ecosystem – ocean, sea, estuary.

REFERENCE BOOKS

- ❖ Patterns of primary production in the biosphere. H.F.W. Lieth (1978).
- ❖ Fundamentals of Ecology. Agarwal S. K. (1992).
- ❖ The Biosphere. Bradbury I. K. (1990)
- ❖ Handbook of Limnology and water pollution with practical methodology
- ❖ Das S. M. (1989). Environment and Plant Ecology. Etherington J. R. (1975).
- ❖ Deterministic mathematical models in population ecology.
- ❖ Freedman H. I.(1980). Quantitative Plant Ecology.
- ❖ Greig Smith P. (1983). Comparative Plant Ecology.
- ❖ Grisms J. P. et .al (1988). Quantitative and dynamic ecology.
- ❖ Kershaw K. S. (1964). Concept of ecology.
- ❖ Kormondy E. J. (1966). Ecology.
- ❖ Krebs C. J. (1978). Manual of plant Ecology.
- ❖ Misra K. C. (1989). Proceedings of the school of plant ecology.
- ❖ Misra R. and Das R. R. (1971).
- ❖ Ecology. Odum E. P. (1971). Fundamentals of Ecology.
- ❖ Odum E. P. (3rd ed. 1996). Fundamentals of Ecology.
- ❖ Odum E. P. and Gary W. Barrett (6th ed. 2010). Principles of Environment Sciences.
- ❖ Pandeya S. C. eta .l (1963). on the Origin of Species. London: John Murray (always seek out the first edition, facsimile version, and avoid later editions).
- ❖ Darwin, C. 1859. Genetics and the Origin of Species. New York: Columbia Univ. Press (there are several later editions, and the title changed in the last).
- ❖ Dobzhansky, T. 1937. The Genetical Theory of Natural Selection. Oxford: Oxford Univ. Press (there is a later edition).

- ❖ Fisher, R. A. 1930. *Phylogenetic Systematics*. Urbana: Univ. Illinois Press (an English translation of a book published earlier in German).
- ❖ Hennig, W. 1966. *Systematics and the Origin of Species*. New York: Columbia Univ. Press (there is a later edition, with a different title).
- ❖ Mayer, E. 1942. *Factors of Evolution*. Philadelphia: Blakiston (publication of this book, written in the early 1940's, was delayed because of war, and then the translation from Russian to English was also delayed; it has been reprinted by Univ. Chicago Press).
- ❖ Schmalhausen, 1949. *Tempo and Mode of Evolution*. New York: Columbia Univ. Press (again, there is a later edition, with a different title). Simpson, G. G. 1944.

M.Sc. – I (SEMESTER – III)
MAJOR MANDATORY COURSE – IV (PRACTICAL) [2 CREDITS]

[TOTAL PRACTICAL: 10]

CYTOGENETICS AND CROP IMPROVEMENTS [8 PRACTICALS]

- ❖ Determination of mitotic index
- ❖ Karyotype analysis of *Allium cepa*
- ❖ Meiotic studies in *Allium cepa*
- ❖ Study of floral biology of crop plants
- ❖ Hybridization techniques in crop plants
- ❖ Genetic problems on gene mapping in higher plants
- ❖ Determination of allele frequency in population

PLANT ECOLOGY [2 PRACTICALS]

- ❖ Study of Phytoplankton
- ❖ Study of species diversity indices

M.Sc. – I (SEMESTER – III)
MAJOR MANDATORY COURSE – V (PRACTICAL) [2 CREDITS]
[TOTAL PRACTICAL: 10]

BIOTECHNOLOGY AND GENETIC ENGINEERING [8 PRACTICALS]

- ❖ Preparation of MS medium for Plant tissue culture and sterilisation techniques.
- ❖ Callus culture.
- ❖ Micro propagation.
- ❖ Cell suspension culture and estimation of secondary metabolites.
- ❖ *Agrobacterium* mediated transformation (Hairy roots/ tumor formation).
- ❖ Isolation of plasmid.
- ❖ Nucleotide sequence BLAST and construction of phylogenetic tree.

PLANT ECOLOGY [2 PRACTICALS]

- ❖ Study of Population dynamics.
- ❖ Determination of frequency, Density, Abundance, Dominance and IVI of the plant community.

M. SC. II (SEMESTER – III)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ANGIOSPERM TAXONOMY
FLORISTICS AND BIOSYSTEMATICS

[TOTAL LECTURES: 30]

UNIT I: **[15]**

- ❖ **Floristic:** Need and significance of floristic studies, methodology, analysis and data presentation.
- ❖ **Taxonomic literature:** General taxonomic indexes, world floras and manuals, monographs and revisions, bibliographies, catalogues, review serials, periodicals, glossaries, dictionaries, cultivated and economic plants, maps and cartography, biographical references, dates of publication, location of type specimens, dictionaries and addresses, colour charts, outstanding botanical libraries.
- ❖ **Botanical keys:** Diagnostic, synoptic and artificial keys-Single access (sequential)-bracketed and indented keys and multi-access keys, edge-punched and body-punched (polyclave) keys, tabular and lateral keys; computerized keys, their merits and demerits.
- ❖ **Biosystematics:** Aims, concepts of species, steps in biosystematic study, biosystematic categories-ecotype, ecospecies, cenospecies, comparium, methods in biosystematic studies, ecotypic variations and taxonomy, scope and limitations.

UNIT: II **[15]**

- ❖ **Origin of agriculture and rise of food crops:** Introduction, food plants, origin and spread of *Homo sapiens*, centres of plant domestication of major crops, crop dispersal and distribution.
- ❖ **Crop plants and their wild relatives:** Cereal grains (rice, sorghum, wheat), legumes (chickpea, black gram, mung bean, cowpea, moth bean), starch plants (banana, yam), fruits (apple, citrus, grape, peach, strawberry), vegetables (cucurbits)
- ❖ **Morphological variations, systematic position, interrelationships, phylogeny and economic importance of following families:** ROSIDS: Rhamnaceae, Moraceae, Urticaceae, Cucurbitaceae, Begoniaceae, Casuarinaceae, Lythraceae, Onagraceae, Myrtaceae, Melastomataceae, Rutaceae, Meliaceae, Sapotaceae, Lecythidaceae, Solanaceae.

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
ANGIOSPERM TAXONOMY
FLORISTICS AND BIOSYSTEMATICS

[10 PRACTICALS]

- ❖ Herbarium technique
- ❖ Botanical keys
- ❖ Study of intra and interpopulation variations of species
- ❖ Identification of taxa with the help of computerized key
- ❖ Study of weeds found in the region

- ❖ Study of wild relatives of crop plants (*Cucumis*, *Abelmoschus* and *Vigna*)
- ❖ Study of crop plants and their wild relatives (Fruit and vegetables)
- ❖ Description, sketching, classification and identification of families: ROSIDS- Rhamnaceae, Moraceae, Urticaceae, Cucurbitaceae, Begoniaceae, Casuarinaceae, Lythraceae, Onagraceae, Myrtaceae, Melastomataceae, Rutaceae, Meliaceae, Sapotaceae, Lecythidaceae, Solanaceae and identification of wild and cultivated plants represented in local flora.
- ❖ Any additional practical/s based on theory syllabus will be added whenever necessary.

REFERENCE BOOKS:

- ❖ **Cronquist, A. 1981.** An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
- ❖ **Cronquist, A. 1988.** The Evolution and Classification of Flowering Plants (2nd ed.) Allen Press, U.S.A.
- ❖ **Davis, P. H. and V. H. Heywood 1991.** Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi.
- ❖ **Endress Peter, K. 1994.** Diversity and Evolutionary Biology of Tropical Flowers. Cambridge.
- ❖ **Judd Walter S., Campbell C. S., Kellogg, E. A., Stevens P.F. and M. J. Donoghue 2008.** Plant Systematics-A Phylogenetic Approach. Sinauer Associates, INC, Publishers. Sunderland, Massachusetts, USA.
- ❖ **Lawrence, G. H. M. 1951.** Taxonomy of Vascular Plants. Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
- ❖ **Naik, V. N. 1984.** Taxonomy of Angiosperms. Tata McGraw-Hill, New Delhi.
- ❖ **Quicke, Donald, L. J. 1993.** Principles and Techniques of Contemporary Taxonomy. Blakie Academic & Professional, London.
- ❖ **Rao, R. R. 1994.** Biodiversity of India (Floristic Aspects). Bishen Singh Mahendra Pal Singh, Dehra-Dun.
- ❖ **Richard, A. J. 1997.** Plant Breeding Systems. (2ed.) Chapman and Hall.
- ❖ **Shivanna, K. R. and B. M. Johri 1985.** The Angiosperm Pollen: Structure and Function. Wiley Eastern limited, New Delhi.
- ❖ **Taylor, D. V. and L. J. Hickey 1997.** Flowering Plants: Origin, Evolution and Phylogeny. CBS Publishers & Distributers, New Delhi.

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE I (THEORY) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
MOLECULAR GENETICS

[TOTAL LECTURES: 30]

UNIT I:

- ❖ **Microbial Genetics:** Genetic studies in microorganisms with special reference to *Escherichia coli* and *Agrobacterium* sp. Genetic exchange in bacteria- an overview (mutants, conjugation, Transduction and transformation) site directed mutagenesis.
- ❖ **The Genetics of Viruses:** The structure and life cycle of bacterial virus, Mapping the bacteriophage genome (Phage phenotypes, genetic recombination in phage, fine structure and deletion mapping), T4 genetic map, bacteriophage X 174.

UNIT II

- ❖ **Bioinformatics, Genomics and Proteomics:** Bioinformatics tools for analyzing genomic information; Biological databases, Comparative genomics- Ancient duplications and Palaeopolyploidy, Phylogenetic analysis. Genomes of higher plants- *Arabidopsis*, Rice, Soybean, Maize and grapevine.
- ❖ **Comparative genomics tools and techniques,** macro and microsynteny, evolutionary principles and applications.

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
MOLECULAR GENETICS

[10 PRACTICAL]

- ❖ Study of bacterial conjugation.
- ❖ Study of bacterial transduction.
- ❖ Study of transformation in *E. coli*.
- ❖ Induction of mutation and study of mutants in *E. coli*.
- ❖ DNA isolation from plants using CTAB method and purification and quantification of DNA.
- ❖ Study of restriction digestion analysis by gel electrophoresis.
- ❖ Study of polymorphism in crop plants using molecular markers (RAPD/ ISSR).
- ❖ GUS expression in plants.

REFERENCE BOOKS:

- ❖ **Alberts B. et al** 1994. Molecular biology of the cell 3rd Edition Garland Publishing, New York.
- ❖ **Brown T. A.** 1998. Genomes. John Wiley and sons Singapore.
- ❖ **Griffith A. J. F. Miller J. H., Suzuki D. T., Lewontin R. C. and W. M. Gelbart** 1996. An introduction to Genetics Analysis. 6th Edition W. H. Freeman New York.
- ❖ **Gupta P. K.** 1985. Genetics Rastogi Publications Meerut.

- ❖ **Jain H. K.** 1999. Genetics Principles, Concepts and Implications. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- ❖ **Klug W. S. and Cummings M. R.** 1983. Concepts of Genetics. Charles E. Merrill Publishing Company London.
- ❖ **Latchman D. S.** 1990. Gene regulation an eukaryotic perspective. Unwin Hyman Publication London.
- ❖ **Lewin, B.** 2008, Genes IX Oxford University Press, New York.
- ❖ **Singh B. D.** 1990. Fundamentals of Genetics. Kalyani Publishers Ludhiana.
- ❖ **Strickberger M. W.** 1996 Genetics 3rd Edition MacMillan Publishing Co. New Delhi.
- ❖ **Twyman R. M.** 1998. Advanced molecular Biology. Viva Books Pvt. Ltd. New Delhi.
- ❖ **Wolfe S. L.** 1993. Molecular and cellular biology. Wadwith Publishing Co. California USA.

Journals:

- ❖ Annual review of Microbiology
- ❖ Journal of Cytology and Genetics
- ❖ Cytologia
- ❖ Caryologia
- ❖ Indian Journal of Experimental Biology
- ❖ Journal of Experimental Botany
- ❖ Trends in Biotechnology (Elsevier)

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ENERGY, ECOLOGY AND ENVIRONMENT
EXPERIMENTAL ECOLOGY AND ENERGY STUDY

[TOTAL LECTURES: 30]

UNIT I: **[15]**

- ❖ **Ecological Methods:** Autecology and synecology, Bigger unit of vegetation, Seed output, Germination capacity. Various methods involved in aquatic studies.
- ❖ **Systems Ecology:** Introduction and basic elements of system ecology.
- ❖ **Construction of model:** Conceptual model, Auxiliary variables, Forester diagrams.
- ❖ **Phytoremediation:** Classification of phytoremediation and their application.
- ❖ **Rain harvesting:** Harvesting system and techniques, Methods and Advantages
- ❖ **Vermicomposting technology** – Role of earth worm, Process of vermin composting and applications.

UNIT II: **[15]**

- ❖ **Energy Sources:** Biomass as a source of energy, Composition of biomass (cellulose, hemicelluloses, lignin), Terrestrial biomass, aquatic biomass.
- ❖ **Bio energy:** Energy plantation, Social forestry, Silviculture, Energy farms, Petroleum plants, Hydrocarbon from higher plants (*Hevea*, *Euphorbia*), Algal hydrocarbons.
- ❖ **Energy from Waste:** Biogas production, Bio village concept, Eco Cook stoves.
- ❖ **Conventional energy sources:** Coal and Natural gas, Hydropower, Nuclear energy
- ❖ **Non-conventional energy:** Solar energy, Wind energy, Geothermal energy

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE PRACTICAL COURSE III [2 CREDIT]
ECOLOGY PAPER XV: PRACTICAL COURSE III

[10 PRACTICALS]

- ❖ Survey and mapping of area by GPS.
- ❖ Seed germination under various treatments for tree species.
- ❖ Study of seed output and reproductive capacity.
- ❖ Study of petro crops and energy plants.
- ❖ Study of effect of natural light intensity on primary productivity of an aquatic ecosystem.
- ❖ Setting up of an ecological model.
- ❖ Use of ecological model in the field study.
- ❖ Determination of Leaf Area Index (LAI).
- ❖ Induction of rooting.
- ❖ Determination of calorific value of wood

REFERENCE BOOKS:

- ❖ **Agarwal S. K.** (1992): Fundamentals of Ecology. New Delhi: Ashish Publishing House.
- ❖ **Bradbury I. K.** (1990): The Biosphere. Published by John Wiley & Sons, Chichester.

- ❖ **Das S. M.** (1989): Handbook of Limnology and water pollution with practical Methodology. Published by South Asian Publishers, New Delhi.
- ❖ **Etherington J.R.** (1975): Environment and plant ecology: aims and development. Publisher Wiley.
- ❖ **Freedman H. I.** (1980): Deterministic mathematical models in population ecology. Marcel Dekker Inc., New York.
- ❖ **Greig Smith P.** (1983): Quantitative Plant Ecology. *Publisher:* WILEYBLACKWELL
- ❖ **Grims J. P. et al** (1988): Comparative Plant Ecology. Covlend, Dalbeattie, Kirkudrightshire [Scotland]: Castlepoint Press.
- ❖ **Hashimoto Y et al** (1990): Measurement techniques in plant sciences. San Diego, Calif.: Academic Press
- ❖ **Kershaw K. A.** (1964): Quantitative and dynamic ecology. Publisher: Edward Arnold
- ❖ **Kormondy E. J.** (1996): Concept of ecology. Publisher: Benjamin Cummings.
- ❖ **Krebs C. J.** (1978): Ecology. Harper & Row., New York.
- ❖ **Lieth H. F. et al** (1973): Patterns of primary production in the biosphere. Kluwer Academic Publishers-Plenum Publishers.
- ❖ **Misra K. C.** (1989): Manual of plant ecology. Oxford and IBH Publishing Co., New Delhi.
- ❖ **Misra R. and Das R. R.** (1971): Proceedings of the school of plant ecology. Publisher: Calcutta Oxford & IBH Pub. Co.
- ❖ **Odum E. P.** (1971): Ecology. Publisher: Saunders
- ❖ **Odum E. P.** (3rd ed. 1996): Fundamentals of Ecology. Natraj Publishers, Dehra Dun.
- ❖ **Pandeya S. C. et al** (1963): Research methods in plant ecology. Asia Publishing House.
- ❖ **Sharma, P. D.** (2019): Ecology and Environment, Thirteenth edition. Rastogi publication.
- ❖ **Watt K. E. F.** (1973): Principles of Environment Sciences. Published by McGraw-Hill.

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY

DEFENCE MECHANISM AND GENETICS OF HOST PATHOGEN INTERACTION

[TOTAL LECTURES: 30]

UNIT I:

- ❖ **Parasitism and disease development:** Parasitism and pathogenecity and host range, development and disease in plants, stages in development in disease (inoculation, penetration infection, dissemination and perpetuation) of Pathogen.
- ❖ **Chemical weapons of pathogen:** Role of enzymes and toxins in disease development, cell wall degrading enzymes cellulolytic proteolytic, lipolytic toxins lycomarsamine alternic acid, fusaric acid, victorinn and aflatoxins, plant growth regulators, phenols and phytoalexins.

UNIT II

- ❖ **Physiology and biochemistry:** host pathogen interaction, photosynthesis, respiration, proteins and nucleic acids.
- ❖ **Defence mechanism against pathogen:** structural, chemical: induced structural and induced biochemical defences
- ❖ **Genetics of host pathogen interaction:** gene for gene hypothesis, protein for protein hypothesis, antigen antibody reaction, immunoglobulins, application of immunological techniques and physiological specialization
- ❖ **Genetics of disease resistance:** types of resistance, interaction between resistance genes, molecular marker assisted selection.

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY

DEFENCE MECHANISM AND GENETICS OF HOST PATHOGEN INTERACTION

[10 PRACTICALS]

- ❖ Quantitative estimation of Cellulases in healthy and infected plants.
- ❖ Quantitative estimation of invertases in healthy and infected plants.
- ❖ Quantitative estimation of pectinases in healthy and infected plants.
- ❖ Quantitative estimation of amylases in healthy and infected plants.
- ❖ Estimation of nucleic acids from healthy and infected plants.
- ❖ Seed viability test: Ninhydrin test, TTC, Floating test.
- ❖ Estimation of proteins from healthy and infected plants.
- ❖ Detection of polyphenols in healthy and infected plants by circular paper chromatography.

Reference Books:

- ❖ Agrios, G. N. (2006). Plant Pathology (5th Edition). Academy Press, London.

- ❖ Aneja, K. R. (1993). Experiments in Microbiology, Plant Pathology and Tissue Culture. New Age international.
- ❖ Cooke, A. A. (1981). Diseases of Tropical and Subtropical Field, fiber and Oilplants.
- ❖ Gangopadhyay, S. (1994). Clinical Plant Pathology. Kalyani Publishers, Daryaganj, New Delhi.
- ❖ Gangulee, H. S. and Kar, A. K. (1992). College Botany Vol. II. New Central Book Agency (P) Ltd., Kolkata. W. B.
- ❖ Jha, D. K. (1993). A text book on Seed Pathology. Vikas Publishing House Pvt. Ltd., 576 Masjid Road, Jangpura, New Delhi-110014.
- ❖ Kuljit, J. (1969). The Biology of parasitic flowering plants. Uni. Of California Press, U. S. A.
- ❖ Mahadevan, A. and Shridhar, R. (1982). Methods in Physiological Plant. PHI Learning Pvt. Ltd., M97 Cannaught Circle, New Delhi.
- ❖ Mehrotra, R. S. (1980). Plant Pathology. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
- ❖ Nair, L. N. (2007). Topics in Mycology and Plant Pathology. New Central Book Agency (P) Ltd., Kolkata. W. B.
- ❖ Neergard, P. (1977). Seed Pathology. Vol. I & II, Macmillan Press, London.
- ❖ Nyvall, R. F. (1979). Field Crop Diseases Handbook.
- ❖ Padoley, S. K. and Mistry, P. B. A manual of plant Pathology.
- ❖ Paul Khurana, S. M. (1998). Pathological problems of Economic Crop Plants and their Management.
- ❖ Plank, J. E. Vander (1968). Plant Diseases, Epidemics and Control. Academy Press, London.
- ❖ Rangaswamy, G. (1975): Diseases of crop plants in India. Diseases of crop Plants in India. PHI
- ❖ Learning Pvt. Ltd., M97 Cannaught Circle, New Delhi.
- ❖ Singh, R. S. (1963): Plant Diseases. Oxford and IBH Publishing

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE – II [2 CREDITS]
PLANT BIOTECHNOLOGY
APPLICATION AND PROSPECTS OF PLANT TISSUE CULTURE

TOTAL LECTURES: 60

UNIT I:

- ❖ **Herbicide resistance:** Glyphosate, Phosphinothreic acid, Atrazine
- ❖ **Insect resistance:** bt genes, structure and functions of cry proteins- mechanism of action. Non-bt genes like protease inhibitors, alpha amylase inhibitor, lectins.
- ❖ **GM crops:** Improvement for nutritional quality – golden rice, oil crop.
- ❖ **Virus resistance:** coat protein mediated, nucleocapsid gene.
- ❖ **Fungal resistance:** PR proteins, Chitinases.
- ❖ **Long shelf-life of fruits and flowers:** use of ACC synthase, polygalacturonase, ACC oxidase.
- ❖ **Drought and salinity stress management in plants:** proline, choline betaine, revolving door model, osmolytes.

UNIT II:

- ❖ Molecular pharming, plantibodies and plants as bioreactors, edible vaccines.
- ❖ Social, ethical, legal aspects of Biotechnology.
- ❖ Secondary metabolite production from callus/ cell suspension cultures.
- ❖ Regulatory mechanisms in releasing GMOs, IPR, Plant breeders rights.

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE PRACTICAL COURSE – II [2 CREDITS]
PLANT BIOTECHNOLOGY
APPLICATION AND PROSPECTS OF PLANT TISSUE CULTURE

[10 PRACTICALS]

- ❖ In vitro culture of any RET plant species.
- ❖ Micropropagation of Banana.
- ❖ In vitro germination of seeds.
- ❖ Micropropagation of any floriculture member (*Gerbera*, *Chrysanthemum*, *Gladiolus*, *Lilium*, Carnations, Rose, Orchids, etc.)
- ❖ Establishment of Hairy root culture (based on availability of strain).
- ❖ Screening of cell cultures for biotic (fungal) / abiotic stress (PEG).
- ❖ Testing anti-microbial effect of different plant extracts.
- ❖ MTT assay for cytotoxicity assessment in plants/cell cultures.
- ❖ Any other practical designed.

M.SC. PART – II (SEMESTER III)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
PLANT PHYSIOLOGY
STRESS PHYSIOLOGY OF PLANTS

[TOTAL LECTURES: 30]

UNIT I:

- ❖ **Water stress:** Causes of water stress: Arid and Semiarid regions, Drought effect on physiological processes in plants, Mechanism of stomatal action, various mechanisms of drought resistance in plants, Antitranspirants, Drought hardening, Transgenic approach.
- ❖ **Flooding stress:** Nature of waterlogging stress. Effect of flooding stress on physiological processes in plants. Wetland and non-wetland species. Mechanism of waterlogging tolerance.
- ❖ **Gaseous stress:** Effect of elevated CO₂ concentration on plant metabolism, Effect of air pollutant SO₂ and O₃ on plants.
- ❖ **Biotic stress:** Effect of fungal infection on plant metabolism, Biochemical mechanism of disease resistance, Allelopathy, crop-weed interaction, Biopesticides

UNIT II:

- ❖ **Salt stress:** Definition of saline soil, Causes of soil Salinization. A brief outline of Salt affected soils in India, Physiological responses of plants to salinity stress, Halophytes and glycophytes mechanism of salinity tolerance in higher plants, Genetic engineering for salt tolerance.
- ❖ **Radiation stress:** Influence of high light intensity on photosynthesis, Photoprotection mechanisms, Effect of UV radiations on plants, Mechanism of UV tolerance.
- ❖ **Oxidative stress:** Generation of reactive oxygen species, Effect of ROS on metabolism, ROX detoxification mechanisms in plants, Transgenic approaches.

M. SC. PART – II (SEMESTER III)
MAJOR ELECTIVE PRACTICAL COURSE – II (PRACTICAL) [2 CREDITS]
PLANT PHYSIOLOGY
STRESS PHYSIOLOGY OF PLANTS

[10 PRACTICALS]

- ❖ Measurement of osmotic potential of controlled and stressed tissue.
- ❖ Determination of chlorophyll stability index.
- ❖ Effect of salt stress on plant growth.
- ❖ Effect of PEG induced drought stress on osmolyte accumulation.
- ❖ Study of effect of fungal infection on polyphenol oxidase activity.
- ❖ Study of free radicals scavenging enzyme catalase in healthy and infected plants.
- ❖ Study of super oxide dismutase in healthy and infected plants.
- ❖ Effect of different light intensity on growth and phenolics.
- ❖ Study of protein profiling under stress conditions.

REFERENCE BOOKS

- ❖ Buchanan, B.B., Gruissem, W. And Jones, R.L. (2000) Biochemistry and Molecular Biology of Plants. Wiley-Blackwell
- ❖ Cherry, J. H. (ed.) (1989) Environmental Stress in Plants: Biochemical and Physiological Mechanisms Associated with Environmental Stress Tolerance in Plants (NATO ASI Series G, vol. 19). Springer, Berlin.

- ❖ Fitter, A.H. and R.K.M. Hay, (1987) *Environmental Physiology of Plants*. Academic Press, San Diego, CA, 2nd. ed.
- ❖ Hale, M.G. and Orcutt, D.M. (1987) *The Physiology of plants under stress*. John Wiley and Sons, New York.
- ❖ Kozlowski, T.T. (1984) *Flooding and Plant Growth*. Ed. T.T. Kozlowski. Academic Press, Orlando, FL
- ❖ Levitt, J. (1980) *Responses of plants to environmental stresses: Vol. II, Water, Radiation, Salt and other*. Academic Press, New York
- ❖ Mansfield, T.A. (1976) *Effects of Air Pollutants on Plants*. CUP Archive
- ❖ Mehrotra, R. S. (1980): *Plant Pathology*. Tata McGraw-Hill
- ❖ Paleg, L.G. and Aspinal, D. (1982) *The Physiology and Biochemistry of Drought resistant in Plants*. Academic Press, Sydney.
- ❖ Poljakoff-Mayber, A. and Gale, J. (eds.). (1975) *Plants in saline environments*. Springer Verlag, New York, USA
- ❖ Rice, E. L. (1974) *Allelopathy*, Academic Press, New York, San Francisco, London

M. SC. PART – II (SEMESTER – III)
RESEARCH PROJECT [4 CREDITS]

M. SC. PART – II (SEMESTER – IV)
MAJOR MANDATORY COURSE –I (THEORY) [4 CREDITS]
PLANT PHYSIOLOGY AND METABOLISM

[TOTAL LECTURES: 60]

UNIT I:

- ❖ Active and passive mechanisms of solute transport, Mechanisms of phloem loading and unloading of photoassimilates, source-sink relationship and its applications.

UNIT II:

- ❖ **Photosynthesis:** Photo oxidation of water and C₃ pathway, RUBISCO, Sub classification of C₄ plants, PEPcase, ecological significance and modification of CAM.
- ❖ **Respiration:** Overview of plant respiration, Anaerobic respiration, Modern concept of electron transport and ATP synthesis. Inhibitors of respiration. Gluconeogenesis.

UNIT III:

- ❖ **Nitrogen metabolism:** Nitrate and ammonium assimilation; amino acid biosynthesis.
- ❖ **Secondary metabolites:** Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

UNIT IV:

- ❖ **Plant growth regulatory substances:** Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action of auxins, cytokinins, gibberellins, ethylene and abscisic acid.
- ❖ **Stress physiology:** Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.

REFERENCES BOOK

- ❖ **Bidwell, R. C. S.** (1979): Plant Physiology. Macmillan
- ❖ **Bonner, J.** and Varner, J.E. (1972): Plant Biochemistry. IBH.
- ❖ **Buchanan, B.B., Gruissem, W. And Jones, R.L. (2000)** Biochemistry and Molecular Biology of Plants. Wiley-Blackwell
- ❖ **Edwards G. and Walker D., eds.** (1983). C₃, C₄: mechanisms, and cellular and environmental regulation, of photosynthesis. Oxford: Blackwell Scientific Publications.
- ❖ **Govindjee, H.** (ed.) (1982): Photosynthesis, Vol. 1 and Vol. 2. Academic Press, N.Y. (Vol. 1); 0-12- 294302-2 (Vol. 2))
- ❖ **Hopkins, W. C.** (1995): Introduction to Plant Physiology. Wiley, New York.
- ❖ **Krishnamurthy, H.N.** (1992): Physiology of Plant Growth and Development. Atma Ram and Sons, Delhi.
- ❖ **Marschner, H. W.** (1986): Mineral nutrition of Higher Plants. First Edition, Academic Press, Elsevier Science Ltd.
- ❖ **Marschner, H. W.** (2003): Mineral nutrition of Higher Plants. Second Edition, Academic Press, Elsevier Science Ltd.

- ❖ **Moore, T.C.** (1974): Research experience in Plant Physiology, A Laboratory manual. Springer-Verlag, Berlin.
- ❖ **Mukherjee, S.P.** and Ghosh A.N. (1996): Plant Physiology. New Central Book Agency (P) Limited Tata McGraw Hill.
- ❖ **Noggle, G.R.** and Fritz, G. J. (1976): Introductory Plant Physiology. Prentice- Hall, Inc., Englewood Cliffs, NJ.
- ❖ **Pessarakli, M.** (Ed.). (2001). Handbook of Plant and Crop Physiology, 2nd Edition, Revised and Expanded. Marcel Dekker, Inc., New York
- ❖ **Pessarakli, M.** (Ed.). (2005). Handbook of Photosynthesis, 2nd Edition, CRC Press, Taylor & Francis Publishing Company, Florida
- ❖ **Randhir Singh** and Sawhney S. K. (1988): Advances in frontier Areas of Plant Biochemistry. Prentice Hall of India
- ❖ **Sadasivam S.** and Manickam A. (1996): Biochemical methods. New Age International.
- ❖ **Salisbury, F. B.** and Ross, C.W.(1992): Plant Physiology IV ed. Cengage Learning
- ❖ **Sinha R.K.** (2014) Modern Plant Physiology Second Edition, Narosa Publishing House Pvt. Ltd.
- ❖ **Smith, H.** (1975): Phytochrome and Photomorphogenesis. McGraw-Hill Inc.,US
- ❖ **Taiz, L.** and Zeiger, F. (1998, 2002, 2006): The Plant Physiology. Second Edition, Third Edition, Sunderland: Sinauer Associates.
- ❖ **Wilkins, M. B.** (1976): Physiology of Plant Growth and Development. McGraw-Hill Publishing Company Limited

JOURNALS

- ❖ Annual Review of Plant Physiology and Molecular Biology.
- ❖ Annual Review of Plant Physiology
- ❖ Indian Journal of Plant Physiology.
- ❖ Journal of Experimental Botany.
- ❖ Physiologia Plantarum Sweden.
- ❖ Plant Physiology (Bethesda, USA).
- ❖ Plant Cell

M. SC. PART – II (SEMESTER – IV)
MAJOR MANDATORY COURSE – II (THEORY) [4 CREDITS]
PLANT PATHOLOGY (4 CREDITS)

TOTAL LECTURES: [60]

UNIT I **[15]**

- ❖ **History of studies on plant disease:** Beginning of modern plant pathology, Contributions of Prevost, Anton De Bary, Kuhn, Woronin, S. D. Garrett, J. G. Horsfall, K.C. Mehta, T. S. Sadavasivan, M. J. Trimulachari and A. Mahadevan.
- ❖ **Symptomology and Epidemiology:** Disease identification based on symptoms, (external and internal). Epidemiology: epiphytotics (Slow and rapid), disease forecasting.
- ❖ **Methods of Studying plant diseases and their diagnosis:** Field observation, collection of samples, laboratory studies, culturing of pathogenic organisms (fungi, bacteria and mycoplasma), Koch's postulates.
- ❖ **Stages of disease development:** Pre penetration, Penetration, post penetration and colonization.
- ❖ **Defence mechanism in host:** Structural, physiological, genetical and chemical.
- ❖ Role of environmental factors in disease development.

UNIT II **[15]**

- ❖ **Introductory Virology:** History of virology, Nomenclature and classification of plant viruses, ultrastructure of TMV, TYMV and Bacteriophages. Chemistry of plant viruses, isolation and purification of plant viruses. Economic importance of viruses.
- ❖ **MLOs:** Classification, morphology, characteristics and identification techniques of MLOs
- ❖ History, symptomology, causal organism, etiology and management of Viral and/or MLO diseases of Banana, Brinjal, Tomato, Bhendi, Sugarcane, Beans and Tobacco

UNIT: III **[15]**

- ❖ History, symptomology, causal organism, etiology and management of fungal diseases of Rice, Jowar, Wheat, Bajra, Sugarcane, Pigeon pea, Beans, Tomato, Potato, Cabbage, Bhendi, Brinjal, Cucurbits, Chilli, Fig, Onion, Ginger, and Turmeric.

UNIT: IV **[15]**

- ❖ History, symptomology, causal organism, etiology and management of fungal and/or bacterial diseases of Maize, Cotton, Sunflower, Groundnut, Soybean, Sesame, Coffee, Banana, Grapes, Mango, Coconut, Pomegranate, Teak, Shisham, Bamboo and Rose.

REFERENCE BOOKS:

- ❖ Agrios, G. N. 2006. Plant Pathology, 5th Edition
- ❖ Aneja, K. R. 1993. Experiments in Microbiology, plant pathology and Tissue culture.
- ❖ Cooke, A. A. 1981. Diseases of Tropical and Subtropical field, Fiber and oil plants.
- ❖ Gangopadhyay, S. 2004: Clinical Plant Pathology.
- ❖ Kuijit, J. 1969: The Biology of parasitic flowering plants.
- ❖ Mahadevan, A. and R. Shridhar, 1982. Methods in physiological plant pathology
- ❖ Agarwal A. and Mehrotra, R. S. 2012: Plant Pathology.

- ❖ Nyvall, R. F. 1979. Field Crop Diseases Handbook.
- ❖ Paul Khurama, S. M. 1998: Pathological Problems of Economic crop plants and their management.
- ❖ Planke, J. E. and, 1968: Disease Resistance in plants.
- ❖ Planke, J. E. Vander. 1963: Plant Diseases Epidemics and control.
- ❖ Rangaswami, G. 1979: Diseases of crop plants in India.
- ❖ Singh R. S. 2009: Plant Diseases, 9th Edition.

CURRENT AND BACK – VOLUMES OF FOLLOWING PERIODICALS:

- ❖ Journal of phytopathology
- ❖ Indian journal of phytopathology
- ❖ Journal of Mycology and plant pathology
- ❖ Annual review of plant pathology

M. SC. PART – II (SEMESTER - IV)
MAJOR MANDATORY COURSE - III (PRACTICAL) [2 CREDITS]

PLANT PHYSIOLOGY [10 PRACTICALS]

- ❖ Determination of lipid peroxidation in plants under stress.
- ❖ Determination of rate of respiration in germinating seeds under aerobic and anaerobic conditions.
- ❖ Estimation of free amino acid.
- ❖ Study of enzyme Nitrate reductase.
- ❖ Effect of plant growth regulators on seed germination and seedling growth.
- ❖ Estimation of enzyme Phenyl Alanine Ammonia Lyase.
- ❖ Determination of chlorophyll a/b ratio in C₃ and C₄ plants.
- ❖ Measurement of relative water content in plants under stress.
- ❖ Estimation of proline content of control and naturally stress induced plants.
- ❖ Analysis of sugars and amino acids from phloem sap.

M. SC. PART – II (SEMESTER - IV)
MAJOR MANDATORY COURSE – IV (PRACTICAL) [2 CREDITS]
PLANT PATHOLOGY

[10 PRACTICALS]

- ❖ **Fungal Diseases:** Club root, Damping off, White rust, Early and late Blight, Downy mildew, Powdery mildew, Smut, Rust, Bunt, Blast, Leaf spot, Anthracnose, Die back, Rot and Wilt.
- ❖ **Bacterial Diseases:** Citrus canker, Blight of Rice, Angular leaf spot of cotton, Oily spot of Pomegranate (Bacterial Blight).
- ❖ **Mycoplasmal Diseases:** Grassy shoot disease and Little leaf.
- ❖ **Viral Disease:** TMV, PMV, Banana bunchy top and YVMV.
- ❖ **Phanerogamic plant Diseases:** Total and partial root and stem parasites.
- ❖ **Nematode Disease:** Root knot.
- ❖ Estimation of chlorophylls, sugars and polyphenols from healthy and infected leaves.

M. SC. PART – II (SEMESTER - IV)
MAJOR MANDATORY ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ANGIOSPERM TAXONOMY
PHYLOGENY AND FLORAL BIOLOGY OF ANGIOSPERMS

[Total Lectures: 60]

UNIT I:

- ❖ **Origin of Angiosperms:** Pre-cretaceous and Cretaceous fossil angiosperms, time of origin of angiosperms, cradle of angiosperms, probable ancestors of angiosperms-Isoetes-monocotyledon theory, Coniferales-amentiferae theory, Gnetales-angiosperm theory, Anthostrobilus theory, Caytonian theory, Stachyosporphylospormae theory, Pteridosperm theory, Pentoxylales theory and Durian theory, monophyletic verses polyphyletic origin of angiosperms.
- ❖ **Floral Biology-I:** Evolution of flower, evolution of floral biology in basal angiosperms, coevolution of flowering plant and insects, sex in flowers, sex distribution in plants, types of pollination, chasmogamy and cleistogamy; biology of floral parts-calyx, corolla, androecium, pollen, style and stigma.
- ❖ **Floral Biology-II:** Anemophily, hydrophily, ornithophily, cheiropterophily, entomophily- beetle, fly, bee, wasp, fig wasp, butterfly, moth, carpenter bee pollination.

UNIT II

- ❖ **History of botanical exploration in India:** Beginning of botany in India, contributions made in earlier phase by Garcia d'Orta, C. Acosta, Van Rhee, John Burman, John Koenig, Robert Kyd, Buchanan, Roxburgh, N. Wallich, William Griffith, Robert Wight, Thomas Thomson, J. D. Hooker, Collet, Brandis, T. Cooke, Duthie, Fyson, Gamble, Haines, Parkinson, Prain, Santapau, and recent works with special emphasis on Maharashtra. Botanical Survey of India (BSI).
- ❖ **Morphological variations, systematic position, interrelationships, phylogeny and economic importance of following families:** ASTERIDS-Convulvaceae, Boraginaceae, Rubiaceae, Apocynaceae, Oleaceae, Scrophulariaceae, Bignoniaceae, Lentibulariaceae, Verbenaceae, Lamiaceae
- ❖ Phytogeographical regions and Flowering plants of India.

M. SC. PART – II (SEMESTER III)
MAJOR MANDATORY COURSE – II (PRACTICAL) [2 CREDITS]
ANGIOSPERM TAXONOMY
PHYLOGENY AND FLORAL BIOLOGY OF ANGIOSPERMS

[10 PRACTICALS]

- ❖ Studying features of anemophilous, hydrophilous, ornithophilous, cheiropterophilous, and butterfly, moth and carpenter bee pollinated flowers.
- ❖ Description, sketching, classification and identification of families: ASTERIDS-Convulvaceae, Boraginaceae, Rubiaceae, Apocynaceae, Oleaceae, Scrophulariaceae, Bignoniaceae, Lentibulariaceae, Verbenaceae and Lamiaceae.

REFERENCE BOOKS:

- ❖ **Cronquist, A. 1988.** The Evolution and Classification of Flowering Plants (2nd ed.) Allen Press, U.S.A.
- ❖ **Cronquist, A. 1981.** An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
- ❖ **Davis, P. H. and V. H. Heywood. 1991.** Principles of Angiosperm Taxonomy. Today and Tommorrow Publications, New Delhi.
- ❖ **Manilal, K. S. and M. S. Muktesh Kumar [ed.]. 1998.** A Handbook of Taxonomic Training. DST, New Delhi.
- ❖ **Naik, V. N. 1984.** Taxonomy of Angiosperms Tata McGraw-Hill Publication Com. Ltd. New Delhi.
- ❖ **Quicke, Donald, L. J. 1993.** Principles and Techniques of Contemporary Taxonomy. Blakie Academic & Professional, London.
- ❖ **Rao, R. R. 1994.** Biodiversity of India (Floristic Aspects). Bishen Singh Mahendra Pal Singh, Dehra-Dun.
- ❖ **Taylor, D. V. and L. J. Hickey. 1997.** Flowering Plants: Origin, Evolution and Phylogeny. CBS Publishers & Distributors, New Delhi.
- ❖ **Lawrence, G. H. M. 1951.** Taxonomy of Vascular Plants. Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
- ❖ **Shivanna, K. R. and B. M. Johri. 1985.** The Angiosperm Pollen: structure and Function. Wiley Eastern limited, New Delhi.
- ❖ **Endress Peter, K. 1994.** Diversity and Evolutionary Biology of Tropical Flowers. Cambridge.
- ❖ **Richard, A. J. 1997.** Plant Breeding Systems. (2ed.) Chapman and Hall.
- ❖ **Nayar, M. P. 1996.** Hot Spots of Endemic Plants of India, Nepal and Bhutan. Tropical Botanica Gardens and Research Institute, Palode, Kerala
- ❖ **Ahmedullah, M. and M. P. Nayar. 1987.** Endemic Plants of the Indian Region Vol I. Botanical Survey of India.
- ❖ **Synge, Hugh (ed.). 1980.** The biological aspects of Rare Plant Conservation. John Wiley & Sons.
- ❖ **Judd Walter S., Campbell C. S., Kellogg, E. A., Stevens, P.F. and M. J. Donoghue. 2008.** Plant Systematics. Sinauer Associates, INC, Publishers. Sunderland, Massachusetts, USA. Percival, M. S. 1965. Floral Biology. Pergamon Press, London

M. SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
SPECIAL APPROACHES IN GENETIC IMPROVEMENT OF CROP PLANTS

TOTAL LECTURES: 30

UNIT I:

- ❖ **Functional genomics:** Genome annotation. RNA interference mechanism, synthesis and its applications
- ❖ Virus induced gene silencing (VIGS), VIGS in plant genomic research
- ❖ Transcriptomics and methods of transcriptome analysis
- ❖ Quantitative trait loci (QTL), Methods of QTL analysis by using molecular markers.
- ❖ Mapping population (RIL, NILS, DH, back cross) their mechanism a development. Bulk segregation analysis.

UNIT II:

- ❖ Allele Mining for crop improvement: Approaches for allele mining, significance of novel alleles, applications of allele mining.
- ❖ Marker assisted selection for crop improvement: Selection of markers, breeding schemes involved, gene pyramiding applications of MAS.
- ❖ Epigenetics and Epigenomics for crop improvement
- ❖ Tissue Culture: Anther culture, production of haploids, embryo rescuing and its uses in crop improvement.
- ❖ Production of secondary metabolites, cell line isolation, hairy root culture with some important secondary metabolite production and use of bioreactors.
- ❖ Production of biotic and abiotic resistant plants using tissue culture.

M. SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
CYTOGENETICS AND PLANT BREEDING
SPECIAL APPROACHES IN GENETIC IMPROVEMENT OF CROP PLANTS

[10 PRACTICALS]

- ❖ Study of *In silico* studies (Identification of SSRs, Primer designing and Similarity search analysis using different BLAST programs) and EST analysis in crops.
- ❖ Preparation of linkage map using mapmaker and join map and QTL analysis using QTL Cartographer and QTL Network.
- ❖ Construction of phylogenetic tree among grass species for a particular gene.
- ❖ Callus culture and Cell line isolation.
- ❖ Secondary metabolite production and analysis.
- ❖ Hairy root culture.
- ❖ Micropropagation culture.
- ❖ Anther culture and haploid production.
- ❖ Study of transgenic plants.
- ❖ Detection and estimation of protease inhibitors from cereals/pulses.

REFERENCE BOOKS:

- ❖ Andreas Baxevanis, B. F. Francis Ouellette and B. F. Cuellette 1998 Bioinformatics: A Practical Guide to the analysis of Genes and Proteins, Wiley Publishers, New York Brown
- ❖ T. A. 1999 Genomes. John Wiley and Sons Pvt. Ltd. Singapore.
- ❖ Chawala H. S. 2000 Introduction to Plant Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd.
- ❖ Chrispeels M. J. and Sadava D. E. 1994 Plants, Genes and Agriculture. Jones and Barlett Publishers Boston, USA.
- ❖ Jagota A. 2000 Data Analysis and Classification for Bioinformatics. Published by Bioinformatics by the bay Press. University of Michigan, USA
- ❖ Durbin R, Sean R., Eddy, Anders Krogh, Graeme M.1999 Biological Analysis- Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press.
- ❖ Kumar U. 2005. Methods in Plant Tissue culture Agrobios Jodhpur India.
- ❖ Gupta P. K. 2010 Plant Biotechnology. Rastogi Publications Meerut.
- ❖ Gustafson J. P. 1990 Gene manipulation in plant improvement I and II. Plenum Press London.
- ❖ Gustafson J. P. 2000 Genomes. Kluwer Academic Plenum Publishers New York USA.
- ❖ Lal R. and Lal S. 1993, Genetic engineering of plants for crop improvement. CRC Press.
- ❖ Liu Ben Hui 1998 Statistical Genomics: Linkage Mapping and QTL Analysis. CRC Press LLC Florida USA.
- ❖ Manibhushanrao K. and Mahadevan A. 1996 Recent developments in biocontrol of Plant pathogens. Today and Tomorrow's printers and publishers New Delhi.
- ❖ Mitra Sandhya 1996, Genetic Engineering Macmillan India Ltd.
- ❖ Mount D. W. 2001 Bioinformatics Sequence and Genome Analysis. Cold Spring Harbour
- ❖ Old R. W. and Primrose S. B. 1989 Principles of Gene Manipulation. Blackwell Scientific Publ Oxford UK.

M.SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
ENERGY, ECOLOGY AND ENVIRONMENT
ENVIRONMENTAL ISSUES, ASSESSMENT AND RESTORATION

TOTAL LECTURES: 30

UNIT I:

- ❖ **Air pollution:** Classification, Acidic precipitation, causes and consequences. Air pollution control measures monitoring devices. Environmental issues.
- ❖ **Water pollution:** Classification of water pollutants. Oxygen demanding pollutants and their activity. Pathogens, nutrients, salts, heat, heavy metals and pesticides. Radioactive and oil pollutants. Self-purification of natural streams. Oxygen sag analysis.
- ❖ **Environmental issues:** Ozone – Positive and negative influence of ozone. Air quality loss, nuclear winter, vehicular and industrial gases, global climate change.

UNIT II:

- ❖ **Environmental impact assessment:** Concept, scope and objectives of EIA, Biological monitoring programme, Bio indicators and environmental monitoring, Remote sensing and GIS.
- ❖ **Environmental impact assessment:** Methodology, Component of EIA, Environmental management, Indian environmental law.
- ❖ **Natural resources:** Types of resources, Conservation and management of resources Soil resources, Forest resources, ecological and economic significance.
- ❖ **Recycling of natural resources:** Waste management, Waste disposal.
- ❖ **Ecotourism and Eco-friendly measures:** Guideline, Sustainability of ecotourism.

M. SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
ENERGY, ECOLOGY AND ENVIRONMENT
ENVIRONMENTAL ISSUES, ASSESSMENTS AND RESTORATION

[10 PRACTICALS]

- ❖ Measurement of dust fall.
- ❖ Measurement of noise pollution.
- ❖ Study of garbage types and their analysis
- ❖ Study of biological indicators
- ❖ Study of IUCN red list categories
- ❖ Study of macro and microphytes
- ❖ EIA exercise
- ❖ EIA reporting
- ❖ Comparison of plant communities from polluted and non-polluted areas.
- ❖ Effect of effluents on soil microflora

REFERENCE BOOKS:

- ❖ **Adriano, D. C. and Johnson, A. H.** (1989): Acidic precipitation, vol. II. John Wiley *Publishers*.
- ❖ **Balkrishnan, M., Borgstrom, R. and Bie, S. W.** (1994): Tropical Ecosystems. Oxford and IBH *Publishing Co.*
- ❖ **Dash, M. C.** (1993): Fundamentals of Ecology. Tata *Mc.Graw Hill Publishing Company Ltd.* New Delhi.
- ❖ **De, A. K.** (1994): Environmental Chemistry. New Age international *publishers*.
- ❖ **Good, R. E. et al** (1978): Fresh water wetlands. Margraf *Publishers*.
- ❖ **Gregory S.** (1988): Recent climatic changes: A regional approach. Kluwer Academic *Publisher*.
- ❖ **Lal, J. B.** (1987): Environmental Conservation. *Publisher:* International Book Distributors.
- ❖ **Misra K. C.** (1989): Manual of plant ecology. Oxford and IBH Publishing Co., New Delhi.
- ❖ **Owen, M. and Black, J. M.** (1990): Waterfall Ecology. Blackie *Publishers*, Glasgow, Scotland.
- ❖ **Sharma, P.D.** (2019): Ecology and Environment, Thirteenth edition. Rastogi publication.
- ❖ **Kormondy, Edward J.** (1996): Concepts of Ecology, Fourth edition, Prentice Hall of India private limited.

M. SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY
INDUSTRIAL MYCOLOGY

TOTAL LECTURES: 10

UNIT I:

- ❖ **Role of fungi in industry:** Scope and their utility.
- ❖ **Commercial fungal strains:** Selection, improvement, development and their maintenance, commercial sources of fungal strains.
- ❖ **Fermentation:** Industrial alcohol production through fermentation
- ❖ **Industrial production of organic acids:** citric, fumaric, itaconic and kojic acid through fermentation.
- ❖ **Industrial production of enzymes:** amylases, pectinases and invertases.

UNIT II:

- ❖ **Industrial production of vitamins:** vitamin B12, riboflavin, vitamin A through fermentation Industrial production of gibberellins through fermentation.
- ❖ **Industrial production of antibiotics:** penicillin, streptomycin, griseofulvin
- ❖ **Production of ergot alkaloids:** Ergotxin
- ❖ **Cultivation of Edible fungi:** large and small-scale cultivation technique of *Agaricus bisporus* and *Pleurotus sajor-kajoo* and its nutritional value.

M. SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
MYCOLOGY AND PLANT PATHOLOGY
INDUSTRIAL MYCOLOGY

[10 PRACTICALS]

- ❖ Preparation of pure cultures: *Aspergillus* and *Penicillium*.
- ❖ Maintenance of fungal strains using different methods.
- ❖ Detection of citric acid from mycelial biomass using circular paper chromatography
- ❖ Production of industrial alcohol by fermentation technique.
- ❖ Estimation of antibiotics from fungal biomass by broth culture.
- ❖ Preparation of spawn for cultivation of mushroom.
- ❖ Cultivation of *Pleurotus sajor-kajoo*.
- ❖ Qualitative estimation of amylases and cellulases from fungal biomass.

Reference Books:

- ❖ Casida, L. E. Jr. (1964). Industrial Microbiology. John Wiley and Sons, USA
- ❖ Whipps, J. M. and Lumsden, R. D. (1989). Biotechnology of fungi for improving plant growth. Press Syndicate of the University of Cambridge, UK
- ❖ Turner (1971). Fungal metabolism. Academic Press, USA
- ❖ Atal (1978). Indian Mushroom Science-I. Indo American Literature House
- ❖ Kannaiyan (1980). A hand book of edible mushrooms. Today's and Tomorrow's. Publ.
- ❖ Purkhyastt (1976). Indian edible mushrooms. Firma KLM, 1976 Cornell University

- ❖ Smith, J. F. and Barry, D. R. The filamentous fungi Vol.I Industrial Mycology Vol.II and III. Edward Arnold, London.
- ❖ Dodge, C.W. (1935). Industrial Mycology.
- ❖ Prescott, S. G. and Dunn, C. D. (1959). Industrial Microbiology. AVI Pubn. Com. Westport, CT
- ❖ Christensen, C. M. (1975): Mould, Mushrooms and Mycotoxins. University of Minnesota press, Minneapolis
- ❖ Rose, A. H. (1961). Industrial Microbiology. Butterworths, London 53
- ❖ Singer, R. (1961). Mushrooms and Truffles cultivation and utilization. Leonard Hill, Ltd.,
- ❖ Rhodes, A. and Fletcher, D. L (1966). Principles of industrial microbiology. Pergamon Press, Oxford, UK
- ❖ Gray, W. D. (1970). The use of fungi as food and food processing. Cleveland, Oh: CRC Press, USA
- ❖ Lodder, J. (1970). The Yeast. North- Holland, Amsterdam
- ❖ Chang, S. T. and Hays, W. A. (1978). The biology and cultivation of edible mushrooms. Academic Press, New York.
- ❖ Aneja, K. R. (1993). Experiments in Microbiology, Plant Pathology and Tissue Culture.
- ❖ Onions, A. H. S. D. Allsopp and Eggins, H. O. W. (1981). Smith's Introduction to Industrial Mycology. New Age International Publishers
- ❖ Barger, G. (1931). Ergot and Ergotism. Edward Arnold
- ❖ Fletcher, J. T., White, P. F. and Gaze, R. H. (1989). Mushrooms: Pest and Disease Control. Intercept, Ltd., VCH Publishers, Suite 909, 220 East 23rd Street, New York,

Journals

- ❖ Annual Review of Plant Pathology.
- ❖ Canadian Journal of Botany.
- ❖ Mycologia.
- ❖ Indian Journal of Plant Pathology.

M.SC. PART – II (SEMESTER IV)
MAJOR MANDATORY COURSE – I (THEORY) [2 CREDITS]
PLANT BIOTECHNOLOGY
APPLICATION, REGULATION AND PATENTING BIOTECHNOLOGY

[TOTAL LECTURES: 60]

UNIT I:

[15]

- ❖ Applications of tissue culture in horticulture, forestry, medicine, sericulture, Floriculture and pharmaceuticals.
- ❖ Application of biotechnology in environmental protection, Pollution control, phytoremediation, wastewater treatment.

UNIT II:

[15]

- ❖ **Biological Nitrogen Fixation:** Mechanism of N₂ fixation, Symbiotic N₂ fixation, Mechanism of N₂ fixation in root nodules, Nod genes, Nif genes, Hup genes.
- ❖ Use of microbes in Industry and agriculture.
- ❖ Protein sequence and nucleotide sequence databases- introduction and importance.

M. SC. PART – II (SEMESTER IV)
MAJOR MANDATORY COURSE – II (PRACTICAL) [2 CREDITS]
PLANT BIOTECHNOLOGY
APPLICATION, REGULATION AND PATENTING BIOTECHNOLOGY

[10 PRACTICALS]

- ❖ Synthesis of nanoparticles.
- ❖ Characterization of nanoparticles.
- ❖ Growth curve of *E. coli*.
- ❖ Culturing method in Algae.
- ❖ Culturing method in fungi.
- ❖ Protoplast isolation by mechanical method.
- ❖ Demonstration of phytoremediation for polluted sites.
- ❖ Demonstration of HPLC.
- ❖ Any other practical designed

REFERENCE BOOKS

- ❖ Altman, A. 1998. Agricultural Biotechnology. Marcel Dekker, New York.
- ❖ Gupta, P. K. 2000. Elements of Biotechnology. Rastogi Publisher, Meerut, India.
- ❖ Glick, B. R. and Pasternak, J. J. 1994. Molecular Biotechnology- Principles and applications of recombinant DNA. ASM Press, Washington.
- ❖ Mitra, S. 1996. Genetic Engineering- principles and practice. Mcmilan, India ltd.
- ❖ Technology information, forecasting and assessment council (TIFAC). 2002. Sources of patent information and patent agents. Technology Bhavan, New Delhi.
- ❖ Technology information, forecasting and assessment council (TIFAC). 2002. Lecture notes on patents. Technology Bhavan, New Delhi.

M. SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – I (THEORY) [2 CREDITS]
PLANT PHYSIOLOGY
APPLIED PLANT PHYSIOLOGY

[TOTAL LECTURES: 30]

UNIT I:

- ❖ **Nutriophysiology:** Foliar diagnosis of critical nutrient status. Applications of lime and gypsum as soil additives. Role of chelates in mineral utilization. Foliar applications of mineral elements. Biofertilizers.
- ❖ Regulation of phosphate uptake. Symbiotic associations to improve availability of phosphorus and the mechanism involved.
- ❖ **Crop growth and its regulation:** Seed dormancy, Growth analysis of crop plants and its significance. Factors controlling crop productivity, Harvest Index (HI), Water Use Efficiency (WUE).
- ❖ **Source:** Sink capacity in crop plants and its significance.

UNIT II:

- ❖ **Plant growth regulators in agriculture and horticulture:** Mode of applications of PGR's Pre sowing soaking treatment, foliar application, drenching, dipping and other modes Ethylene and ethylene generating compounds, Brassinosteroids, strigolactones, karrikins, metatopolins, plant growth retardants, weedicides and their action.
- ❖ **Biostimulants:** organic and natural substances, inorganic compounds, beneficial microorganisms, Plant-derived smoke, smoke-water, and smoke compounds.
- ❖ Nanotechnology in agriculture, postharvest loss reduction and food processing, synthesis of nanoparticles.

M. SC. PART – II (SEMESTER IV)
MAJOR ELECTIVE COURSE – II (PRACTICAL) [2 CREDITS]
PLANT PHYSIOLOGY
APPLIED PLANT PHYSIOLOGY

[10 PRACTICALS]

- ❖ Effect of meta-topolin in *in vitro* grown cultures.
- ❖ Effect of pre-sowing treatments of Plant Growth Regulatory substances (PGRs) on crop growth.
- ❖ Synthesis of nanoparticles and their effect on seedling growth
- ❖ To study effect of source manipulation on sink capacity.
- ❖ Growth analysis of any two crops.
- ❖ Effect of weedicides on plant metabolism (chlorophyll/nitrate reductase activity/sugars)
- ❖ To study the methods of breaking seed dormancy
- ❖ Effect of gibberellic acid (GA) and on seed germination
- ❖ Effect of fruit ripening on sugars/photopigments

REFERENCE BOOKS

- ❖ Asana, R.D. and Sarin, M.N. (1968) Crop physiology in India. Tech. Bull. 16. Indian Coun. Agric. Res. (Agric. Ser.)
- ❖ Buchanan, B.B., Gruissem, W. And Jones, R.L. (2000) Biochemistry and Molecular Biology of Plants. Wiley-Blackwell
- ❖ Evans, L.T. (1972): Crop Physiology. Some Case Histories. Cambridge, NY Fageria,
- ❖ N. K. (1992): Maximizing crop yield. CRC Press
- ❖ Fitter, A.H. and R.K.M. Hay (1987) Environmental Physiology of Plants. (Second Edition) Academic Press, San Diego, CA
- ❖ Gupta U.S. (1988) Progress in Crop Physiology. Oxford and IBH. Pub. Co.
- ❖ Gupta U.S. (1995) Production and Improvements of Crops for Drylands. Oxford and IBH. Pub. Co.
- ❖ Krishnamurthy, H.N. (1992): Physiology of Plant Growth and Development. Atma Ram and Sons, Delhi.
- ❖ Nickell, L.G. (1982) Plant Growth Reggulators – Agricultural Uses. Springer-Verlag, New York
- ❖ Pessarakli, M. (Ed.). (2001). Handbook of Plant and Crop Physiology, 2nd Edition, Revised and Expanded. Marcel Dekker, Inc., New York
- ❖ Taiz, L. and Zeiger, F. (1998, 2002, 2008): The Plant Physiology. (Second Edition 1998, Third Edition 2002, Fourth Edition 2008) Sunderland: Sinauer Associates.

JOURNALS

- ❖ Annual Review of Plant Physiology and Molecular Biology.
- ❖ Annual Review of Plant Physiology.
- ❖ Indian Journal of Plant Physiology.
- ❖ Journal of Experimental Botany.
- ❖ Physiologia Plantarum Sweden.
- ❖ Plant Physiology (Bethesda, USA).
- ❖ Plant Cell.

M.SC. PART – II (SEMESTER IV)
RESEARCH PROJECT [6 CREDITS]