



जननायक चंद्रशेखर विश्वविद्यालय, बलिया  
Jananayak Chandrashekhar University, Ballia



**(w.e.f. 2018-2019)**

**SEMESTER SYLLABUS STRUCTURE  
M.Sc. (BOTANY)**

## M.Sc. (BOTANY) PREVIOUS YEAR

### FIRST SEMESTER

**500 MARKS**

PAPER	DESCRIPTION	INTERNAL	EXTERNAL	MARKS
PAPER I (BOT 101)	MICROBIOLOGY, PLANT VIROLOGY & BACTERIOLOGY	25	75	100
PAPER II (BOT 102)	MYCOLOGY	25	75	100
PAPER III (BOT 103)	PHYCOLOGY AND LICHENS	25	75	100
PAPER IV (BOT 104)	BRYOPHYTES	25	75	100
PRACTICAL (BP 105)	BASED ON PAPER 101-104		100	100
	<b>TOTAL</b>	<b>100</b>	<b>400</b>	<b>500</b>

### SECOND SEMESTER

**500 MARKS**

PAPER	DESCRIPTION	INTERNAL	EXTERNAL	MARKS
PAPER I (BOT 201)	PTERIDOPHYTA	25	75	100
PAPER II (BOT 202)	GYMNOSPERMS & PALAEOBOTANY	25	75	100
PAPER III (BOT 203)	ANGIOSPERM: TAXONOMY, MORPHOLOGY & ECONOMIC BOTANY	25	75	100
PAPER IV (BOT 204)	ECOLOGY, PLANT-SOIL RELATIONSHIP	25	75	100
PRACTICAL (BP 205)	BASED ON PAPER 201-204		100	100
	<b>TOTAL</b>	<b>100</b>	<b>400</b>	<b>500</b>

## M.SC. (BOTANY) FINAL YEAR

### THIRD SEMESTER

**500 MARKS**

PAPER	DESCRIPTION	INTERNAL	EXTERNAL	MARKS
PAPER I (BOT 301)	PLANT PHYSIOLOGY	25	75	100
PAPER II (BOT 302)	GENETICS AND CYTOGENETICS	25	75	100
PAPER III (BOT 303)	PLANT BREEDING & BIOSTATISTICS	25	75	100
PAPER IV (BOT 304)	CELL BIOLOGY AND BIOCHEMISTRY	25	75	100
PRACTICAL (BP 305)	BASED ON PAPER 301-304		100	100
	<b>TOTAL</b>	<b>100</b>	<b>400</b>	<b>500</b>

### FOURTH SEMESTER

**500 MARKS**

PAPER	DESCRIPTION	INTERNAL	EXTERNAL	MARKS
PAPER I (BOT 401)	ANATOMY, EMBRYOLOGY AND MORPHOGENESIS	25	75	100
PAPER II (BOT 402)	BIOTECHNOLOGY AND TISSUE CULTURE	25	75	100
PAPER III (BOT 403)	MOLECULAR BIOLOGY AND BIOLOGICAL TECHNIQUES	25	75	100
PAPER IV (BOT 404) IV-A(BOT 404A ) IV-B(BOT 404B ) IV-C(BOT 404C)	SPECIAL PAPERS (ANY ONE OF THESE) ENVIRONMENTAL BOTANY ADVANCED PLANT PHYSIOLOGY PLANT PATHOLOGY	25	75	100
PRACTICAL (BP 405)	BASED ON PAPER 401-403	-	50	50
PRACTICAL (BP 406)	SPECIAL PAPER:404A/ B/ C	-	50	50
	<b>TOTAL</b>	<b>100</b>	<b>400</b>	<b>500</b>

**Note:** There will be 9 questions in each paper and candidate has to attempt only 5 questions. **Q.1** will carry short answers and will be **compulsory** based on units I - IV. **Two** questions will be set from **each unit**, out of which one question has to be attempted. Candidate must obtain minimum pass marks in Theory and Practical Examinations separately.

**M.Sc. (Botany) Practical  
Marks Distribution  
(w.e.f. 2018- 2019)**

<b>M.Sc Ist Semester</b>	<b>100 Marks</b>
Paper I	15
Paper II	15
Paper III	15
Paper IV	15
Class Record and collections	10
Spot (5) 5×2	10
Viva	10
Seminar	10
<b>M.Sc IInd Semester</b>	<b>100 Marks</b>
Paper I	10
Paper II	10
Paper III	10
Paper IV	10
Class Record	10
Herbarium collections	20
Spot (5) 5×2	10
Viva	10
Seminar	10
<b>M.Sc IIIrd Semester</b>	<b>100 Marks</b>
Paper I	15
Paper II	15
Paper III	15
Paper IV	15
Class Record and collections	10
Spot (5) 5×2	10
Viva	10
Seminar	10
<b>M.Sc IVth Semester (BP 405+BP 406)</b>	<b>100 Marks</b>
<b>General Paper Practical (Based on Paper I to III)</b>	<b>50</b>
Paper I	08
Paper II	08
Paper III	08
Class Record and collections	08
Spot (5) 5×2	10
Viva	08
<b>Special Paper Practical (Paper IV)</b>	<b>50</b>
Paper IV	10
Class Record and collections	5
Viva	10
Dissertation(Experiment based)	25

# SEMESTER-I: Paper I

MM:25+75=100

## BOT 101: MICROBIOLOGY, PLANT VIROLOGY & BACTERIOLOGY

### UNIT I

1. Plant virus classification, structure, transmission, detection
  - a. Nomenclature and classification of plant viruses.
  - b. Range of plant virus particle and its genomic organization.
  - c. Nature of plant viruses.
  - d. Morphological, anatomical, and biochemical changes in virus infected plants.
  - e. Transmission of plant viruses and their relationship with vectors.
  - f. Purification and electron microscopy of viruses.
  - g. Virus detection by serological and nucleic acid hybridization methods.

### UNIT II

2. Plant virus replication, sub-viral pathogens, and techniques
  - a. Infection and replication of plant viruses.
  - b. Modern methods of plant virus disease control.
  - c. Structure, replication and pathogenicity of viroids
  - d. Structure and replication of virus infecting bacteria.
  - e. MLO structure and multiplication.

### UNIT III

3. Bacteria- History, classification, structure and genetics
  - a. History of microbiology.
  - b. Classification of Bacteria and Archaeobacteria based on Bergey's Manual of Systematic Bacteriology.
  - c. Bacterial cell structure, function of cell components.
  - d. Bacterial genome structure, replication, expression and recombination, and plasmids.

### UNIT IV

4. Bacterial metabolism, microbiological applications
  - a. Bacterial nutrition and metabolism, including Nitrogen fixation.
  - b. Antibiotics and their mode of action.
  - c. Decomposition of organic matter in soil, cycling of essential elements in nature, and Biofertilizers.
  - d. Microorganisms in food processing-Cheese, butter, milk, bread.
  - e. Microorganisms in relation to biotechnology: Production of alcohol, beverages, organic acid, vitamins and enzymes.
  - f. Water borne pathogenic microbes, role of microorganism in sewage disposal.

### Internal Assessment

**25**

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER-I: Paper II

**BOT 102: MYCOLOGY**

**M.M. 25+75=100**

### UNIT I:

1. General Account of Fungi
  - a. Status of fungi.
  - b. Detailed fungal Classification of Alexopoulos and Mims.
  - c. Mode of nutrition of fungi and their physical and chemical requirement for growth and reproduction.
  - d. Reproduction, hormonal mechanism of sexual reproduction.
  - e. Heterokaryosis, parasexuality, heterothallism.

### UNIT II:

- f. Methods of isolation and culturing of fungi.
- g. Fossil fungi.
- h. Mycorrhizae.
- i. Fungi as a biocontrol agent.
- j. Economic importance of fungi-
  - i. Utilization of fungi by man as food, in food processing, in production of organic acid, vitamins and enzymes.
  - ii. Harmful activities: Deterioration of material by fungi, fungi as an agent of plant and human diseases.

### UNIT III:

2. Characteristic features, systematic position, thallus organization, reproduction, phylogeny and interrelationships of the principal classes of fungi with special reference to following genera:

#### A. Myxomycota:

- i. Myxomycetes- *Stemonitis*.
- ii. Plasmodiophormycetes- *Plasmodiophora*.

#### B. Eumycota:

##### a. Mastigomycotina:

- i. Chytridiomycetes- *Synchytrium*, *Allomyces*.
- ii. Oomycetes- *Saprolegnia*, *Phytophthora*, *Pythium*, *Peronospora*, *Sclerospora*.

##### b. Zygomycotina:

- i. Zygomycetes: *Pilobolus*, *Entomophthora*

### UNIT IV:

##### c. Ascomycotina:

- i. Ascomycetes: *Taphrina*, *Penicillium*, *Protomyces*, *Phyllactinia*

##### d. Basidiomycotina:

- i. Basidiomycetes: *Puccinia*, *Uromyces*, *Melampsora*, *Ustilago*, *Cyathus*.

##### e. Deuteromycotina:

- i. Deuteromycetes: *Fusarium*, *Colletotrichum*, *Alternaria*, *Cercospora*.

### Internal Assessment

**25**

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER-I: Paper III

M.M. 25+75=100

### BOT 103: PHYCOLOGY AND LICHENS

#### UNIT I:

##### Phycology:

1. General account of Algae
  - a. Study of important systems of classifications, criteria used in algal classifications including recent trends up to order.
  - b. Range of thallus structure and organization.
  - c. Algal Pigment.
  - d. Nature of reserved food products.
  - e. Reproductive diversity, life history patterns and alternation of generations.
  - f. Economic and environmental aspects of algae.
  - g. Isolation and culture techniques of algal groups.

#### UNITII:

2. Characteristics features, systematic position, thallus organization, reproduction, phylogeny and interrelationships of the principal classes of algae with special reference to-
  - a. **Cyanophyceae:** *Lyngbya, Gloeotrichia, Stigonema.*
  - b. **Chlorophyceae:** *Pandorina, Eudorina, Chlorella, Microspora, Enteromorpha, Ulva, Sphaeroplea. Cladophora, Stigeoclonium, Fritschiella, Zygnema, Bulbochaete, Mougeotia, Caulerpa, Valonia, Nitella.*

#### UNIT III:

- c. **Xanthophyceae:** *Botrydium.*
- d. **Bacillariophyceae:** *Navicula, Melosira.*
- e. **Phaeophyceae :** *Ectocarpus, Dictyota, Laminaria, Fucus.*
- f. **Rhodophyceae :** *Batrachospermum, Gelidium, Gracilaria, Polysiphonia.*

#### UNIT IV:

##### Lichens:

1. A general account of lichens and its symbionts, thallus structure, reproduction, physiology,
2. Classification and distribution.
3. Chemistry of lichens, Isolation of symbionts and synthesis of thallus.
4. Economic importance of lichens.

#### Internal Assessment

**25**

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER-I: Paper IV

M.M. 25+75=100

### BOT 104: BRYOPHYTES

#### UNIT I:

1. General account of Bryophytes
  - a. General characteristics and life cycle of Bryophytes
  - b. Broad outline classification of Bryophytes.
  - c. Ecology and Physiology of Bryophytes
  - d. Reproductive biology of Bryophytes.
  - e. Geographical distribution of Bryophytes with special reference to India.
  - f. Bryophytes as indicators of mineral enrichment and environmental pollution.
  - g. Economic importance of bryophytes.
  - h. Peristome structure and its significance in the classification of mosses.
  - i. Evolution of sporophyte in bryophyte.

#### UNIT II:

2. Characteristic features, classification, gametophytic and sporophytic organization (morphology, anatomy and their distribution in India) of the principle classes of bryophytes with special reference to following genera:
  - a. MUSCI:
    - i. *Sphagnum*
    - ii. *Polytrichum*
    - iii. *Takakia*

#### UNIT III:

- b. ANTHOCEROTAE:
  - i. *Anthoceros*
  - ii. *Notothylas*
  - iii. *Dendroceros*

#### UNIT IV:

- c. HEPATICAE:
  - i. *Calobryum*
  - ii. *Porella*
  - iii. *Plagiochasma*
3. Origin, evolution, fossil history, phylogeny of principal classes: Hepaticae, Anthocerotae and Musci.

#### Internal Assessment **25**

1. Short test/ Quiz 10
2. Long Test 15

## M. Sc. Semester-I Practical (BP 105)

### Paper I- Microbiology, Plant Virology and Bacteriology

1. Preparation of Nutrient media and sterilization technique
2. Gram's staining and Antibiotic susceptibility test of bacteria
3. Inoculation techniques for growth of bacterial population
4. Isolation of microorganisms from different natural sources- soil, water and sewage
5. Bacteriological examination of water, milk and milk product
6. Identification of symbiotic bacteroids of *Rhizobium*
7. Symptomatology of virus

### Paper II- Mycology

1. Study of following genera of fungi-  
*Stemonitis, Synchytrium, Saprolegnia, Phytophthora, Pythium, Peronospora, Sclerospora, Pilobolus, Taphrina, Penicillium, Protomyces, Phyllactinia, Puccinia, Melampsora, Ustilago, Lycoperdon, Geaster, Cyathus, Fusarium, Colletotrichum, Alternaria, Cercospora,*
2. Isolation and culture of fungi
3. Herbarium (Plant/ plant parts with fungal disease)

### Paper III- Phycology and Lichen

1. Study of following genera  
**Chlorophyceae-** *Pandorina, Eudorina, Chlorella, Hydrodictyon, Scenedesmus, Enteromorpha, Ulva, Sphaeroplea, Cladophora, Stigeoclonium, Pithphora, Frittschiella, Zygonema, Bulbocheate, Mougeotia*  
**Cyanophyceae-** *Microcystis, Lyngbya, Gleotrichia, Stigonema*  
**Xanthophyceae-** *Botrydium*  
**Bacillariophyceae-** *Navicula*  
**Phaeophyceae-** *Ectocarpus, Dictyota, Laminaria*  
**Rhodophyceae-** *Batrachospermum, Gelidium, Polysiphonia*
2. External morphology and preparation of slides of Lichens

### Paper IV- Bryophytes

1. Study and Identification of following genera with suitable preparation  
*Sphagnum, Polytrichum, Anthoceros, Notothylas, Porella, Plagiochasma,*



## **M. Sc. Semester-I**

### **Book References**

#### **Paper I- Microbiology, Plant Virology and Bacteriology**

1. Pelczar, M.L., Reid, R.D. & Chan, E.C.S. (2009). Microbiology. Tata McGraw-Hill, New Delhi.
2. Prescott, L.M., Harley, J.P. & Klein, D.A. (2010). Microbiology. McGraw-Hill, New York.
3. Singh, R.P. (2017). Microbiology. Kalyani Publishers, New Delhi
4. Sharma, P.D. (2016). Microbiology. Rastogi Publishers, Meerut, U.P.
5. Mandahar, C.L. (1978). Introduction to Plant Viruses. S.Chand & Co.Ltd., Delhi.
6. Baveja, C.P. (2017). Text Book of Microbiology. Arya Publications, New Delhi.
7. Maheshwari, D.K. & Dubey, R.C. (2013). A Text Book of Microbiology. S.Chand & Co.N.Delhi.
8. Tortora, G.J., Funke, B.R. & Case, C.L. (2016). Microbiology-An Introduction. Pearson Education India, New Delhi.
9. Sastry, A.S. & Bhat, K.S. (2018). Essentials of Practical Microbiology. Jaypee Brothers Medical Publishers, New Delhi.
10. Mahapatra, P.K. (2008). Textbook of Environmental Microbiology. IK International Publishing House Pvt.Ltd., New Delhi.

#### **Paper II- Mycology**

1. Alexopoulos, C.J., Mims, C.W. & Blackwell, M. (1996). Introductory Mycology. John Wiley & Sons, Inc., New York.
2. Webster, J. & Weber, R. (2007). Introduction to Fungi, 3<sup>rd</sup> ed, Cambridge University Press, London.
3. Singh, R.P. (2010). Fungi, Central Book Depot, Allahabad, U.P.
4. Mehrotra, R.S. & Aneja, R.S. (1998). An Introduction to Mycology. New Age Intermediate Press, New Delhi
5. Vashistha, B.R., Sinha, A.K. & Kumar, A. (2016). Fungi, S.Chand & Co.Ltd., Delhi.
6. Aneja, K.R. & Mehrotra, R.S. (2015). An Introduction to Mycology. New Age International Pvt Ltd, New Delhi.
7. Mishra, S.R. (2010). Textbook of Mycology. Discovery Publishing House Pvt Ltd, New Delhi.
8. Hait, G. (2016). A Textbook of Mycology. New Central Book Agency, New Delhi.

#### **Paper III- Phycology and Lichen**

1. Smith, G.M. (1974). Cryptogamic Botany. Vol. I (Algae and Fungi). TMH publishing Company Ltd., New Delhi.
2. Fritsch, F.E. (1935). The Structure and Reproduction of Algae, Vol. I, Cambridge University Press, Cambridge, UK.
3. South, G.R. & Whittick, A. (1987). Introduction to Phycology. Blackwell Scientific Publication. London
4. Round, F.E. (1986). The Biology of Algae. Cambridge University Press, Cambridge.
5. Kumar, H.D. (1988). Introductory Phycology. Affiliated East-West Press Ltd. New Delhi.
6. Vashistha, B.R., Sinha, A.K. & Kumar, A. (2016). Algae, S.Chand & Co.Ltd., Delhi.
7. Smith, A.L. (1921). Lichens. Cambridge University, Cambridge
8. Muthukumar, S. & Tarar, J.L. (2006). Lichen Flora of Central India. Dattsons, Nagpur
9. Ahmadjian, V. & Hale, M.E. (1973). The Lichens. Academic Press, London.
10. Upreti, D.K. & Nayaka, S. (2004). A Field Guide to the Common Lichens of Corbett Tiger Reserve. Bishen Singh Mahendra Pal Singh, D.Dun.
11. Upreti, D.K., Divakar, P.K., Shukla, V. & Bajpai, R. (2015). Recent Advances in Lichenology-Modern Method and Approaches in Biomonitoring and Bioprospection, Vol.1, Springer Nature, India.

#### **Paper IV- Bryophytes**

1. Smith, G.M. (1955). Cryptogamic Botany. Vol. II (Bryophytes and Pteridophytes). TMH publishing Company Ltd., New Delhi.
2. Richardson, D.H.S. (1981). The Biology of Mosses. Blackwell Scientific Publishing, Oxford.
3. Rashid, A. (2015). An Introduction to Bryophyta. Vikas Publishing House Pvt. Ltd., New Delhi.
4. Malhotra, M. & Pathak, C. (2012). A Text Book of Bryophyta. Wisdom Press, New Delhi.
5. Vashistha, B.R., Sinha, A.K. & Kumar, A. (2016). Bryophyta, S.Chand & Co.Ltd., Delhi.
6. Sharma, O.P. (2016). Bryophyta. McGraw Hill Education (India) Private Limited, New Delhi

## SEMESTER-II: Paper I

M.M. 25+75=100

### BOT 201: PTERIDOPHYTA

#### UNIT I:

1. General account of Pteridophytes
  - a. Classification of Pteridophytes.
  - b. Ecology of Pteridophytes.
  - c. Distribution of ferns.
  - d. Origin and evolution of Pteridophytes.
  - e. Telome theory and evolution of stellar system
  - f. Heterosporous and seed habit.
  - g. Apogamy and Apospory.
  - h. Physiology of germination of spores and development of fern prothallus.

#### UNIT II:

2. Classification, distribution, morphology, life history and phylogeny of the following classes with special reference to following genera:
  - a. Rhyniopsida - *Rhynia*, *Horneophyton*.
  - b. Psilotopsida - *Psilotum*.
  - c. Lycopsidea -
    - i. Selaginellaes - *Selaginella*.
    - ii. Lepidodendrales - *Lepidodendron*.
    - iii. Isoetales - *Isoetes*.
  - d. Equisetopsida:
    - i. Sphenophyllales - *Sphenophyllum*.
    - ii. Calamitales - *Calamites*.

#### UNIT III:

- e. Primofilices:
  - i. Zygoteridales - *Botryopteris*.
  - ii. Cladolyales - *Cladoxylon*.
- f. Filicopsida
  - Eusporangiatae: Ophioglossales - *Ophioglossum*.
  - Protoleptosporangiatae: Osmundales - *Osmunda*.

#### UNIT IV:

- Leptosporangiatae:
  - i. Schizaeales - *Lygodium*.
  - ii. Pteridales - *Pteris*, *Adiantum*.
  - iii. Dicksoniales - *Pteridium*.
  - iv. Hymenophyllales - *Hymenophyllum*.
  - v. Gleicheniales - *Gleichenia*.
  - vi. Cyatheales - *Cyathea*.
  - vii. Marsileales - *Marsilea*.
  - viii. Salviniales - *Azolla*

<b>Internal Assessment</b>	<b>25</b>
1. Short test/ Quiz	10
2. Long Test	15

## SEMESTER-II: Paper II

M.M. 25+75=100

### BOT 202: GYMNOSPERMS AND PALAEOBOTANY

#### UNIT I:

1. General account of Gymnosperm
  - a. General characteristics of Gymnosperms.
  - b. Classification of Gymnosperms
  - c. Distribution of Gymnosperms with special reference to India.
  - d. Economic importance of Gymnosperms
  - e. Origin and evolutionary tendencies in Gymnosperm.

#### UNIT I:

2. A study of their morphology, structure, life history, interrelationship and phylogeny of the following classes with special reference to the following genera:
  - a. Cycadopsida
    - i. Pteridospermales: *Glossopteris*.
    - ii. Cycadales: *Zamia*.
    - iii. Cycadeoideales (Bennettitales): *Williamsonia*, *Cycadeoidea* (Bennittites).
    - iv. Pentoxylales: with special reference to *Pentoxylon*.

#### UNIT I:

- b. Coniferopsida
  - i. Cordaitales: *Cordaites*.
  - ii. Ginkgoales: *Ginkgo*.
  - iii. Coniferales: *Araucaria*, *Cupressus*, *Thuja*.
  - iv. Taxales : *Taxus*.

#### UNIT I:

- c. Gnetopsida
  - i. Ephedrales : *Ephedra*
  - ii. Gnetales : *Gnetum*
  - iii. Welwitschiales: *Welwitschia*

#### Palaeobotany

1. Types of Fossils, their methods of preservation and methods of study.
2. Applied Palaeobotany: Carbon dating, palaeobotany of coal and petroleum, palynology.
3. Study of Indian Fossil Flora: Gondwana Flora, The Rajmahal Flora, Deccan Intertrappean Flora.
4. Theory of continental drift.

#### Internal Assessment

25

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER-II: Paper-III

M.M. 25+75=100

### BOT 203: ANGIOSPERMS: TAXONOMY, MORPHOLOGY AND ECONOMIC BOTANY

#### UNIT I:

**Taxonomy:** A general account

1. History of plant taxonomy.
2. Systems of Classification: History, outlines, basis, merits and demerits of following classifications-
  - a. Benthom and Hooker
  - b. Hutchinson
  - c. Takhtajan
  - d. Cornquist
3. ICBN (History, Principles and Application.)

#### UNIT II:

4. Field and herbarium techniques.
5. Herbaria and Botanical Gardens of India and World.
6. Organisation and activities of BSI.
7. Taxonomy as a synthetic discipline, Modern trends of taxonomy: Morphology, Cytology, Nucleic Acid Hybridization, Chemotaxonomy, numerical taxonomy and serotaxonomy.

#### UNIT III:

General knowledge of the distinguishing features of the following families with special reference to best flora:

1. **Dicots:** Ranunculaceae, Caryophyllaceae, Capparaceae, Tiliaceae, Fabaceae, Mimosaceae, Caesalpiniaceae, Rosaceae, Apiaceae, Amaranathaceae, , Asclepiadaceae, Rubiaceae, Asteraceae, Acanthaceae, Verbenaceae, Lamiaceae, Scrophulariaceae, Polygonaceae, Euphorbiaceae, Moraceae.
2. **Monocots:** Cyperaceae, Poaceae, Liliaceae, Orchidaceae, Arecaceae, Commelinaceae, Zingiberaceae.

#### UNIT IV:

**Economic botany:**

1. Scope of economic botany, study of economically important plants and plant products.
2. Forest Products: a) Wood Timber and Lumber. b) Resins, gum, tanning, material and cork. c) Rubber and other latex products.
3. Textile plants and products: A general account.
4. Fumitories and masticatories: A general account.
5. Narcotics and Insecticide as plant products.

**Morphology:**

1. Phylogeny and interrelationship of Angiosperm.
2. Morphology of flower with special reference to the morphology of carpel and inferior ovary.

**Internal Assessment** **25**

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER II: Paper –IV

M.M. 25+75=100

### BOT 204: ECOLOGY, BIODIVERSITY AND PLANT-SOIL RELATIONSHIP

#### UNIT I:

1. Plant Ecology and its scope.
2. Autecological studies, gene ecology with emphasis on Indian work
3. Plant communities: characteristics and its classification.
4. Life-forms and biological spectrum.
5. Plant community dynamics and development: succession and climax.
6. Study of plant communities (Analytical and Synthetic characters)
7. Population ecology.
8. Ecological niche.

#### UNIT II:

9. Study of different types of ecosystem.
10. Ecological energetic.
11. Biogeochemical cycles of nutrients in ecosystem.
12. Production ecology, measurement of primary productivity.
13. Ecological adaptation of plants in different ecosystems.
14. Environmental pollution and its consequences

#### UNIT III:

15. Biodiversity and its conservation:
  - a. Introduction to Biodiversity.
  - b. Levels of Biodiversity: Genetic species community and Ecosystem.
  - c. Mega diversity Zones and Hot spots.
  - d. Threats to Biodiversity: Causes of Biodiversity loss species extension.
  - e. Red Data Book. IUCN threat categories.
  - f. Strategies for Biodiversity conservation: Principles of Biodiversity conservation in-situ and ex-situ conservation strategies.

#### UNIT IV:

16. Plant-soil relationship
  - a. Soil properties in relation to plant growth: Physical texture, density, porosity, permeability.
  - b. Soil water, energy concept of soil, water, soil water quantities and their measurement.
  - c. Soil: its origin and development.
  - d. Process of soil formation and soil profile.
  - e. Soil erosion: its causes and effects on environment.
  - f. Methods of soil conservation.

#### Internal Assessment **25**

1. Short test/ Quiz 10
2. Long Test 15

## M. Sc. Semester II Practical

### Paper I- Pteridophytes

1. Monographic study of the sporophyte body of the following

*Selaginella, Lepidodendron, Isoetes, Sphenophyllum, Calamites, Botryopteris, Cladoxylon, Ophioglossum, Osmunda, Lygodium, Pteris, Adiantum, Pteridium, Hymenophyllum, Gleichenia, Cyathea, Marsilea, Azolla*

### Paper II- Gymnosperms and Palaeobotany

1. A study of representative types

*Zamia, Ginkgo, Araucaria, Cupressus, Thuja, Taxus, Ephedra, Gnetum*

2. Study of fossils and fossils slides

### Paper III- Angiosperms, Taxonomy, Morphology and Economic Botany

1. Description of local plant in semi technical language

2. Identification of Angiospermic plants of known family up to the level of genus and species with the help of flora

**Note: - Compulsory excursion- Students have to collect and submit at least 100 plants properly pressed, mounted and arranged according to Bentham and Hooker's classification on Herbarium sheets.**

3. Study of all economically important plants and their products included in syllabus

### Paper IV- Ecology and Plant soil Relationship

1. Autecology observations on selected plant species

2. Study of the vegetation by

i. Transect method

ii. Quadrature method

iii. Point method

3. Study of the environmental factors

i. Climatic factors and their measurement

ii. Edaphic factors, mineral composition of soil, pH, soil profile, moisture content, nitrate, calcium, carbonate

iii. Water Analysis

4. Measurement of Biomass

5. Ecological anatomy of hydrophytes, halophytes and xerophytes

## M. Sc. Semester-II

### Book References

#### Paper I- Pteridophytes

1. Smith, G.M. (1955). Cryptogamic Botany. Vol. II (Bryophytes and Pteridophytes). TMH publishing Company Ltd., New Delhi.
2. Sporne, K.K. (1991). The Morphology of Pteridophytes. B.I. publishing Pvt. Ltd., Bombay
3. Parihar, N.S. (1993). An Introduction to Embryophyta: Vol II-Pteridophyta. Central book Depot. Allahabad
4. Parihar, N.S. (1996). Biology and Morphology of Pteridophytes. Central book Depot. Allahabad
5. Rashid, A. (2015). An Introduction to Pteridophyta. Vikas Publishing House Pvt. Ltd., New Delhi.
6. Vashistha, B.R., Sinha, A.K. & Kumar, A.(2016). Pteridophyta, S.Chand & Co.Ltd., Delhi.

#### Paper II- Gymnosperms and Palaeobotany

1. Coulter, J.M. & Chamberlain, C.J. (1978). Morphology of Gymnosperm. Central book Depot. Allahabad
2. Chamberlain, C.J. (1998). Gymnosperms Structure & Evolution. CBS Publisher & Distributors, New Delhi.
3. Beck, C.B. (2006). Origin and Evolution of Gymnosperm. Columbia University Press
4. Bhatnagar, S.P. & Moitra, A. (2013). Gymnosperms. New Age International Publishers, New Delhi.
5. Govil, C.M. (2014). Gymnosperms: Extinct and Extant. Krishna Prakashan Media (P) Ltd. Delhi
6. Vashistha, B.R., Sinha, A.K. & Kumar, A.(2016). Gymnosperms. S.Chand & Co.Ltd., Delhi
7. Stewart, W.N. & Rathwell, G.W. (1993). Palaeobotany and Evolution of Plants. Cambridge University Press, London

#### Paper III- Angiosperms, Taxonomy, Morphology and Economic Botany

1. Eames, A.J. (1961). Morphology of Angiosperms. McGraw Hill Book Company, New York
2. Davis, P.H. (2011). Principles of Angiosperm Taxonomy. Scientific Publishers, Jodhpur
3. Stace, C.A. (1989). Plant Taxonomy and Biosystematics. Edward Arnold Press, UK
4. Lawrence, G.H.M. (1951). Taxonomy of Vascular Plants. Macmillan, New York
5. Das, S.M. (2013). A Text Book of Plant Taxonomy: theory & Objectives. Wisdom Press, New Delhi.
6. Singh, V. (2010). Taxonomy. Rastogi Publication, Meerut.
7. Subramanyam, N.S. (1995). Modern Plant Taxonomy. Vikas Publishing House Pvt. Ltd. New Delhi.
8. Sambamurty, A.V.S.S. (2014). Taxonomy of Angiosperms. I.K.International Publishing House Pvt. Ltd., New Delhi.
9. Verma, B.K. (2011). Introduction to Taxonomy of Angiosperms. PHI Learning Private Limited, N.Delhi.
10. Subramanyam, N.S.(1996). Laboratory Manual of Plant Taxonomy. Vikas Publishing House Pvt. Ltd. New Delhi.
11. Saxena,N.B.& Saxena,S.(2014).Plant Taxonomy.Pragati Prakashan,Meerut.
12. Kumar,S.(2011).Economic Botany.Campus Books International,New Delhi
13. Kochhar,S.L.(2012). Economic Botany in the Tropics.Laxmi Publications,New Delhi
14. Sambamurty,A.V.S.S.&Subrahmanyam,N.S.(2008).A Textbook of Modern Economic Botany,CBS Publishers 7 Distributors Pvt.Ltd.,New Delhi
15. Sharma,A.K.& Sharma,r.(2015).Taxonomy of Angiosperms and utilization of Plants.Pragati Prakashan,Meerut.
16. Verma,V.(2013).Text Book of Economic Botany.Ane Books Pvt Ltd,New Delhi.

#### Paper IV- Ecology and Plant Soil Relationship

1. Odum,E.(1971). Fundamentals of Ecology. Saunders,Philadelphia
2. Odum, E., Barrick, M. & Barrett, G.W. (2005). Fundamentals of Ecology. Cengage Publishers (India Edition)
3. Chapman, J.L. & Reiss, M.J. (2003). Ecology: Principles and Applications. Cambridge University Press, London
4. Sharma,P.D.(2017).Ecology and Environment. Rastogi Publications, Meerut
5. Siddhartha,K.(2013). Ecology and Environment. Kisalaya Publications, New Delhi
6. Verma,V.(2011).Plant Ecology.Ane Books Pvt.Ltd.,New Delhi.
7. Ambasht,R.S.& Ambasht,N.K.(2008).A Text Book of Plant Ecology.CBS Publishers,Ltd,N.Delhi.
8. Kumaresan,V.& Arumugam,N.(2016).Plant Ecology and Phytogeography.Saras Publications,kanyakumari.
9. Kapur,P.& Govil,S.R.(2004).Experimental Plant Ecology.CBS Publishers Pvt Ltd.,New Delhi.
10. Sharma,P.D.(2015).Environmental Botany and Plant Pathology.Rastogi Publications,Meerut

**M.Sc. (BOTANY) FINAL YEAR**  
**SEMESTER-III: Paper- I**

**M.M. 25+75=100**

**BOT 301: PLANT PHYSIOLOGY**

**UNIT I:**

**1. Water metabolism:**

- a. Cell osmotic quantities: Osmosis, osmotic potential, water potential.
- b. Mechanism of water uptake and translocation: water absorption by roots, root pressure and turgor pressure. Phloem loading and unloading.
- c. Transpiration and its regulation: Stomatal opening and closing.

**2. Photosynthesis:**

- a. General aspects and historical background.
- b. Action spectra, organization of photosynthesis apparatus, pigments and light harvesting complexes, photolysis of water.
- c. Mechanism of electron transport- structure and functions of components of Photosystem I and II, Photophosphorylation.
- d. Proton transport and ATP synthesis in chloroplast- ATP synthetase.
- e. Carbon assimilation: Calvin cycle and its regulation, Photorespiration (C<sub>2</sub> Cycle) and C<sub>4</sub> cycle and their regulation.
- f. CAM pathway, Factors affecting Photosynthesis

**UNIT II:**

**3. Respiration:**

- a. Aerobic and anaerobic respiration.
- b. Glycolysis, Krebs's Cycle and their regulation. Substrate level Phosphorylation.
- c. Pentose phosphate Pathway, Glyoxylate cycle.
- d. Electron Transport System and ATP synthesis.
4. **Lipid Metabolism:** Synthesis of fatty acids and degradation.

**UNIT III:**

**5. Mineral Nutrition:**

- a. Essential and Beneficial elements.
- b. Role and deficiency effects of essential nutrient elements.

**6. Stress Physiology:**

- a. Plant responses to abiotic stress.
- b. Stress Proteins (HSP, LEA).
- c. Water deficit and drought, heat, chilling and freezing, salinity, light and anoxia stress.

**UNIT IV:**

**7. Growth regulators:**

Auxin, Cytokinin, Gibberellin, Ethylene, Brassinosteroids, Polyamines and hormones mediated cell signalling.

**8. Flowering:**

- a. Floral evocation, florigen concept, circadian rhythms, photoperiodism and its regulation.
- b. Vernalization, phytochrome and its functions.
- c. Abscission, dormancy (bud and seed), seed germination and senescence.

**Internal Assessment** **25**

- |                     |    |
|---------------------|----|
| 1. Short test/ Quiz | 10 |
| 2. Long Test        | 15 |



## SEMESTER-III: Paper II

M.M. 25+75=100

### BOT 302: GENETICS AND CYTOGENETICS

#### UNIT I:

##### 1. Inheritance Genetics

- a. Principles of Mendelian inheritance and Interaction of genes: Introduction to Pre Mendelian and Post Mendelian genetics. Complementary, epistasis, inhibitory, Duplicate, Polymeric, Lethal and additive interaction of genes.
- b. Cytoplasmic inheritance: Cytoplasmic inheritance involving chloroplast (*Mirabilis jalapa*, *Zea mays*) and Mitochondria (petite yeasts and cytoplasmic male sterility in higher plants), mitochondrial and chloroplast genomes, interaction between nuclear and cytoplasmic genes (Rubisco and Cytochrome oxidase)
- c. Quantitative Inheritance: Qualitative and Quantitative traits, Continuous variation, Inheritance of quantitative traits, (corolla length in *Nicotiana*, cob length in *Zea mays*), multiple factors hypothesis and heritability.

#### UNIT II:

- d. Population genetics: Gene and genotype frequencies, Hardy-Weinberg law, Factors affecting Hardy-Weinberg equilibrium (selection, mutation, migration and genetic drift).

##### 2. Cytogenetics and induced variation

- a. Structural changes in chromosomes: Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes. Cytological consequences of crossing over in Inversion and translocation heterozygotes Genetics of structural heterozygotes, complex translocation heterozygotes, Robertsonian translocations.

#### UNIT III:

- b. Numerical alterations in chromosomes: Origin, occurrence and meiosis of haploids, aneuploids and euploids. Origin and production of autopolyploids, chromosome and chromatid separation, allopolyploids. Induction and characterization of trisomics and monosomics. Transmission of trisomics and monosomics.
- c. Recombination and Linkage: - Concept of Linkage, types and applications, Concept and Types of Recombination, Molecular mechanism of recombination, Site specific recombination, estimation of recombination percentages and map distances, Gene mapping in Fungi using ordered and unordered tetrads of *Neurospora*. Three point test crosses and estimation of linkage distances in plants. Gene maps and physical maps.

#### UNIT IV:

- d. Sex Determination: Important theories of sex determination, sex determination in plants.
- e. Mutation—Spontaneous and induced mutation, physical and chemical mutagens, molecular basis of mutations.
- f. DNA damage and repair mechanism- Types of DNA damage, enzymes involved in repair of DNA, excision repair, recombination repair and mismatch repair systems.
- g. IS element, transposable elements in prokaryotes and eukaryotes, mechanism of transposition, retroelement, application of transposons.

#### Internal Assessment

25

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER-III: Paper-III

M.M. 25+75=100

### BOT 303: PLANT BREEDING AND BIOSTATISTICS

#### Plant Breeding:

##### Unit-I

1. Plant Genetic resources: Genetic diversity in plants, Penetrance and Expressivity, Pleiotropy, Centres of origin, Importance of genetic diversity in crop improvement and its erosion.
2. Collection and evaluation of germplasm.
3. Competition in natural populations, Inter genotype competition, Environmental variation.
4. Heritability-definition and types, Estimates of heritability.
5. Incompatibility and Male sterility: Genetic, physiological and biochemical basis of incompatibility, Utility of self incompatibility, Evolution of incompatibility mechanism; Genetic and Cytoplasmic male sterility

##### Unit-II

6. Hybridization and its role, Principles of combination breeding and its application.
7. Hybrid breeding in self and cross-pollinated crops. Development of hybrids, Use of male sterility in development of hybrids,
8. Testing of combining ability, prediction of performance of hybrids- single cross hybrid, three way cross hybrid, double cross hybrid, Multiple crosses –composite cross breeding,
9. Back cross method of breeding-theory of transfer of alleles.
10. Heterosis, Theories of heterosis, Environmental heterosis, Inbreeding depression.
11. Methods of direct gene transfer.

##### Unit-III

12. Breeding methods in self fertilizing species –Pedigree method, bulk method, single seed descent, dihaploidy, Genotype assessment, recurrent selection, reciprocal recurrent selection.
13. Breeding methods in cross fertilizing species-Mass selection, family selection, combined selection, inter population selection schemes.
14. Factors affecting efficiency of breeding methods.
15. Breeding methods of important crop plants e.g. wheat, rice.

#### Biostatistics:

##### Unit-IV

1. Importance and scope of Biostatistics.
2. Sample and sampling,
3. Collection and representation of data-tabulation, graphical, diagrammatic
4. Measures of Central tendency
5. Measures of dispersion: range, mean deviation, Standard deviation, Variance, Deviation
6. Tests of significance: Significance and difference in means, Standard error of mean, Standard error of SD, Students't' test , Chi-square test.
7. Analysis of variance (ANOVA).
8. Correlation and regression - Meaning, kinds of correlation, coefficient of correlation, methods of studying correlation. Aims of regression analysis. Kinds of regression analysis.

#### Internal Assessment

**25**

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER-III: Paper- IV

M.M. 25+75=100

### BOT 304: CELL BIOLOGY AND BIOCHEMISTRY

#### CELL BIOLOGY

##### Unit-I

1. Cell structure and function: Structural organization of cell, organization of microtubules and microfilaments, plasmadesmata.
2. Cell organelles (Microbodies, Golgi apparatus, Lysosomes, Endoplasmic Reticulum, Vacuole, Ribosomes, Nucleus, Chloroplast, Mitochondria).

##### Unit-II

3. Cell wall, Plasma membrane and their structural models and functions.
4. Active and Passive uptake of ions- facilitated diffusion, primary and secondary active transport, ion carriers, channel proteins and pumps (Na<sup>+</sup>/K<sup>+</sup> and Ca<sup>2+</sup> pumps).
5. Membrane transport proteins- Plasma membrane H<sup>+</sup>- ATPase, vacuolar H<sup>+</sup>-ATPase and H<sup>+</sup> pyrophosphatases.
6. Cell cycle & Apoptosis: Biochemical and genetic mechanism—
  - a. Mitosis, spindle formation mechanism, cytokinesis, cell plate formation,
  - b. Programmed Cell Death (PCD).
  - c. Meiosis and its significance

##### Unit-III

#### BIOCHEMISTRY

1. Amino acids, Peptides and Proteins:
  - a. Chemical and enzymatic hydrolysis of protein to peptides, amino acid sequencing.
  - b. Secondary structure of proteins, forces responsible for holding of secondary structure. L-helix, M-sheet, super secondary structure,.
  - c. Tertiary structure of protein-folding and domain structure, Quaternary structure.
  - d. Biosynthesis of amino acid.
  - e. Denaturation, degradation and renaturation of protein.
2. Carbohydrate:
  - a. Conformation of monosaccharides, structure and functions of important derivatives of monosaccharides.
  - b. Disaccharides and polysaccharides. Structural polysaccharides-Cellulose and chitin. Storage polysaccharides-starch and glycogen.
  - c. Carbohydrate metabolism: Glycogenesis, gluconeogenesis.

##### Unit- IV

3. Nucleic Acid:
  - a. Biosynthesis of nucleotides.
  - b. Denaturation, degradation and renaturation of nucleic acids.
4. Enzymes:
  - a. General aspects, nomenclature and classification.
  - b. Mode of action, Active sites, reversible and irreversible enzyme inhibition.
  - c. Enzyme kinetics and Michaelis- Menton equation.
  - d. Factors affecting enzymatic reactions.
  - e. Structure and function of co-enzymes.
5. Chromatography

#### Internal Assessment 25

1. Short test/ Quiz 10
2. Long Test 15

## M. Sc IIIrd SEMESTER PRACTICAL

### Paper I- Plant Physiology

1. To determine the Osmotic pressure of vacuolar sap of *Rheo discolor* or *Tradescantia* leaves by Plasmolytic method (50% plasmolysis)
2. To determine the diffusion pressure deficit (water potential) of potato tuber tissue by weighing method
3. To determine the structure, size and frequency of stomata in mesophytic and xerophytic leaves
4. To determine the rate of transpiration of plant i. Weight ii. Potometer method
5. To determine the rate of transpiration by Cobalt Chloride paper method and to calculate transpiration index (TI), Transpiration efficiency (TE) of various leaves
6. To measure the rate of photosynthesis in aquatic plants by Willmotts bubble counting method
7. To study the effect of-i. CO<sub>2</sub>; ii. Light quality and intensity; iii. Injury; iv. Temperature on the rate of photosynthesis in leaves of an aquatic / terrestrial plant
8. To extract the major plant pigments from leaves by different solubility method

### Paper II- Genetics and Cytogenetics

1. Chromosomal Technique- Pretreatment, fixation, staining techniques- Acetocarmine- Fielgen, Banding Technique- G Banding
2. Karyotypic studies- Preparation of mitotic metaphase plates and to draw Camera Lucida drawing of chromosome and study of chromosome morphology Calculation of arm ratios, chromosome formula and symmetry of karyotype, preparation of idiograms and drawing photograph
3. Study of genetic crosses based on Mendel's Laws, modification to Mendel and Interaction of genes

### Paper III- Plant Breeding and Biostatistics

1. Emasculation Techniques
2. Statistic analysis of seed samples and applying suitable statistical test for interpretation as desired
3. Numerical problem and design

### Paper IV- Cell Biology and Biochemistry

#### Cell Biology

1. Preparation of squash for the study of mitosis
2. Preparation of smear for the study of meiosis
3. Meiotic studies- Permanent Slide Studies of various stages of meiosis, study of diakinesis and metaphase bivalent,
4. Model studies for cell organelles

#### Biochemistry

1. To separate the major plant pigments (i) Paper chromatography and (ii) Thin Layer Chromatography to calculate R<sub>f</sub> values of the pigment
2. To extract the free amino acid from germinating seed of mung bean/ black gram and to separate them by two dimensional paper chromatography
3. To determine the R<sub>f</sub> values of a given mixture of amino acids using Circular Paper chromatography
4. To measure the activity of enzyme catalase and to study the effect of – (i) Substrate concentration and (ii) pH on enzyme activity
- 5.. To extract proteins from germinating seeds of moong bean/ black gram and to estimate them by the Biuret test
- 6.. To extract and test the presence of Reducing sugar by Benedict's test
7. Effect of (a) enzyme concentration (b) substrate concentration on the activity of Urease

## **M. Sc. SEMESTER-III**

### **Book References**

#### **Paper I- Plant Physiology**

1. Mukherji, S. & Ghosh, A.K. (2012). Plant Physiology. New Central Book Agency (P) Ltd, London
2. Ridge, I. (1996). Plant Physiology. CBS Publishers & Distributors, New Delhi
3. Malik, C.P. (2014). Plant Physiology. Kalyani Publishers, New Delhi.
4. Salisbury, P.B. & Ross, C.W. (1992). Plant Physiology. Wadsworth Publishing, California.
5. Hopkins, W.G. (1995). Introduction to Plant Physiology. John Wiley & Sons, New York.
6. Pandey, S.N. & Sinha, B.K. (2016). Plant Physiology, Vikas Publishing House Pvt. Ltd, New Delhi.
7. Verma, S.K. & Verma, M. (2012). Plant Physiology, Biochemistry and Biotechnology. S.Chand & Company, Ltd., New Delhi.
8. Noggle, G.R. & Fritz, G.J. (1986). Introductory Plant Physiology. Prentice-Hall of India Pvt Ltd, New Delhi.
9. Devlin, R.M. & Witham, F.H. (1986). Plant Physiology. CBS Publishers & Distributors, New Delhi.

#### **Paper II- Genetics and Cytogenetics**

1. Strickberger, M.W. (2015). Genetics. Pearson Education, India
2. Gardner, E.J., Simmons, M.J. & Snustad, D.P. (2006). Principles of Genetics. Wiley
3. Klug, W.S., Cummings, M.R., Spencer, C.A. & Palladino, M.A. (2016). Concepts of Genetics. Pearson Education, India.
4. Singh, B.D. (2009). Genetics. Kalyani Publishers, New Delhi
5. Gupta, P.K. (2009). Genetics. Rastogi Publishers, Meerut.
6. Gupta, P.K. (2007). Cytogenetics. Rastogi Publishers, Meerut.
7. Prasad, G. (2013). Introduction to Cytogenetics. Kalyani Publisher, New Delhi.
8. Roy, D. (2009). Cytogenetics. Narosa Publishing House, New Delhi

#### **Paper III- Plant Breeding and Biostatistics**

1. Allard, R.W. (1999). Principles of Plant Breeding. John Wiley & Sons, New York.
2. Chaudhary, H.K. (2008). Introduction to Plant Breeding. Oxford & IBH, New Delhi.
3. Ram, M. (2014). Plant Breeding Methods, PHI Learning Pvt. Ltd, Delhi.
4. Singh, B.D. (2014). Plant Breeding-Principles and Methods. Kalyani Publishers, New Delhi.
5. Singh, B.D. (2009). A Text Book of Plant Breeding, Kalyani Publishers, New Delhi.
6. Banerjee, P.K. (2007). Introduction to Biostatistics. Rastogi publication, Meerut.
7. Rastogi, V.B. (2015). Biostatistics. Meditech Publishers, New Delhi.
8. Ramakrishna, P. (2015). Biostatistics. Saras Publication, Kanyakumari
9. Prasad, S. (2009). Elements of Biostatistics. Rastogi Publication, Meerut
10. Ambrosius, W.T. (2010). Topics in Biostatistics. Humana Press. New Jersey.

#### **Paper IV- Cell Biology and Biochemistry**

1. Powar, C.B. (2010). Cell Biology. Himalaya publishing house, Mumbai.
2. Karp, G. (2013). Cell Biology, Wiley
3. Verma, P.S. & Agarwal, V.K. (2016). Cell biology. S. Chand & Company Ltd., New Delhi
4. Rastogi, S.C. (2005). Cell Biology. New age Publishers, New Delhi
5. Goodwin, T.W. & Mercer, E.I. (2003). Introduction to Plant biochemistry. CBS Publishers & Distributors Pvt. Ltd., New Delhi.
6. Day, P.M. & Harborne, J.B. (1997). Plant Biochemistry. Academic Press, UK.
7. Wilson, K. & Walker, J. (2013). Principles and Techniques of Biochemistry and Molecular biology. Cambridge University Press, London.
8. Conn, E.E., Stumpf, P.K., Bruening, G. & Doi, R.H. (2006). Outlines of Biochemistry. Wiley.
9. Lehninger, A.L. (2013). Biochemistry. Kalyani publishers, New Delhi.
10. Jain, J.L., Jain, S. & Jain, N. (2016). Fundamentals of Biochemistry. S. Chand & Company Ltd., New Delhi
11. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2002). Biochemistry. W.H. Freeman & Co. Ltd.

## SEMESTER IV: PAPER –I

M.M.75+25= 100

### **BOT 401: ANATOMY, EMBRYOLOGY AND MORPHOGENESIS**

#### **Unit-I**

#### **ANATOMY**

1. Shoot development: Organization of shoot apical meristem (SAM), Leaf (Marginal meristem).
2. The cambium, its derivative tissues, differentiation of secondary phloem and xylem.
3. Structure of woods in relation to its weight, strength, durability and taxonomic significance.
4. Anomalous secondary growth in roots and stems.
5. Cork cambium and its derivatives.

#### **Unit-II**

6. Abscission layers.
7. Origin of lateral and adventitious roots, root-stem transition.
8. Anatomy in relation to taxonomy.

#### **EMBRYOLOGY**

1. Structure of microsporangium, microsporogenesis and development of male gametophyte.
2. Structure of ovule, megasporogenesis and development of female gametophyte.
3. Pollen-Pistil interaction.
4. Fertilization and its control.

#### **Unit-III**

5. Endosperm: Development, types, haustoria, ruminant endosperm, xenia, metaxenia.
6. Embryogenesis in dicot and monocot.
7. Apomixis, causes and significance.
8. Parthenocarpy.
9. Polyembryony and its induction.
10. Embryology in relation to taxonomy.

#### **Unit-IV**

#### **MORPHOGENESIS**

1. Polarity: Polarity in isolated cells, plasmodia & coenocytes. Expression of polarity in external and internal structure of plants. Role of polarity in developmental pattern.
2. Correlation: Physiological and genetical correlations.
3. Symmetry: Inorganic and organic symmetries. Radial, bilateral and dorsiventral symmetries in Plant body. Development of symmetry.
4. Morphogenesis in *Acetabularia*.

#### **Internal Assessment**

**25**

- |                     |    |
|---------------------|----|
| 1. Short test/ Quiz | 10 |
| 2. Long Test        | 15 |

## SEMESTER -IV: PAPER –II

M.M.75+25= 100

### **BOT 402: BIOTECHNOLOGY**

#### **Unit-I**

##### **TISSUE CULTURE**

1. Plant cell and tissue culture techniques: Plant Cell and Tissue culture: Introduction, history, scope, concept of cellular differentiation, totipotency.
2. Culture media and laboratory requirements.
3. Micropropagation-Organogenesis and embryogenesis.
4. Endosperm and nucellus culture.

#### **Unit-II**

5. Somaclonal variation---applications and reasons for generation.
6. Somatic hybridization –protoplast culture, regeneration and somatic hybridization, cybrids.
7. Production and uses of haploids.
8. Applications of plant tissue culture.

#### **Unit-III**

##### **BIOTECHNOLOGY**

1. Genetic Engineering: Cloning vectors (plasmid and bacteriophage vectors, cosmids, BAC and YACs) and Enzymes (restriction endonucleases, polymerases, reverse transcriptase, alkaline phosphatase, polynucleotide kinase, Ligases, terminal transferases).
2. DNA cloning, preparation of plasmid DNA, Restriction and electrophoresis, ligation.
3. Methods of direct and indirect gene transfer in plants, *Agrobacterium*, Ti and Ri plasmids, application of genetic engineering, transgenic plants for pest and disease resistance, abiotic stress tolerance, production of useful products.
4. Principles and methods of Genetic Engineering, Gene libraries and cDNA libraries, Polymerase chain reaction, DNA fingerprinting.

#### **Unit-IV**

5. DNA Sequencing, Southern blotting, RAPD, RFLP, Restriction mapping.
6. Biotechnology and Human welfare
  - a. Applications of genetically engineered bacteria in crop production and protection, biodegradation of xenobiotics and toxic wastes, production of chemicals, biofuels and medicines.
  - b. Biopesticides and integrated pest management, Biofertilizers, Organic farming.
  - c. Microbes for improving soil fertility.

#### **Internal Assessment**

**25**

- |                     |    |
|---------------------|----|
| 1. Short test/ Quiz | 10 |
| 2. Long Test        | 15 |

## SEMESTER -IV: PAPER –III

M.M. 75+25=100

### BOT 403: MOLECULAR BIOLOGY AND BIOLOGICAL TECHNIQUES

#### Unit-I

1. Genome-Basic concept and organization.
2. Chromosome structure, nucleosome, solenoid and packaging of DNA, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, karyotype analysis, banding patterns. Specialized chromosomes—Polytene chromosomes, lampbrush chromosomes, B chromosomes.
3. Nuclear DNA content, C-value paradox. Structure and Properties of Nucleic acids: Structure, Chemical, Physical and thermal properties of nucleic acids.
4. Dissociation and reassociation kinetics of DNA, Cot curves, Cot  $\frac{1}{2}$  values and its significance.
5. Unique, moderately repetitive and highly repetitive DNA, conformation of nucleic acids. (A, B, Z DNA, t-RNA, m- RNA).

#### Unit- II

6. DNA amplification, molecular genetic maps, genome projects.
7. Allele concept, multiple alleles, isoalleles, pseudoalleles.
8. Genetic Code
9. Gene Structure: Organization and Structure of prokaryotic and eukaryotic genes; structure and role of promoters, exons, introns, terminators and enhancers.
10. DNA Replication: - Mechanism of prokaryotic and eukaryotic DNA replication, replication apparatus, Origins of replication, priming and DNA polymerases.
11. Transcription: RNA polymerases and their role, Transcription apparatus, Transcription in prokaryotes and eukaryotes, Initiation, elongation and termination, RNA processing, reverse transcription, Ribonucleoproteins.

#### Unit-III

12. Regulation of Transcription in prokaryotes and eukaryotes: Operon concept (Lac, Tryptophan, cAMP ) positive and negative regulation of prokaryotic genes, eukaryotic transcription factors, transcriptional and translational control.
13. Translation in prokaryotes and eukaryotes.

#### BIOLOGICAL TECHNIQUES

1. Theory of fixation and important fixatives, storage of fixed material.
2. Different types of stains, their preparation and uses: Safranin, fast green, hematoxylin, iodine, cotton blue, crystal violet, ruthenium red, Janus green, Gram's stains, Acetocarmine.
3. Microtomy: Dehydration, clearing and embedding of material, section cutting, dewaxing.

#### Unit-IV

4. Uses of Basic Instruments: pH meter, oven, incubator, autoclave.
5. Microscopy: Compound (Bright and Dark field), Phase contrast, Fluorescence, Ultra violet and Infra Red, Scanning and Transmission Electron Microscopy.
6. Biochemical Methods: Chromatography, Electrophoresis, Centrifugation, X- ray diffraction.
7. Methods of quantitative analysis-
  - a. Spectrophotometry, MS, NMR, ESR, ORD/CD spectrometers.
  - b. Radioisotopic methods: Geiger Muller & Liquid Scintillation Counters, Autoradiography.
  - c. DNA Chip technology and Microarrays.
  - d. Mass Spectrometry for genome and proteome analysis.
  - e. Biosensors.
  - f. Elementary knowledge of IPR and Patenting.

#### Internal Assessment

25

1. Short test/ Quiz

10 2. Long Test

15



## SEMESTER -IV: SPECIAL PAPERS (IV)

### Paper – IVA

#### BOT 404A: ENVIRONMENTAL BOTANY

M.M. 75+25=100

#### Unit –I

1. Introduction: Relation of man with environment, National and International effects on environmental problems, applied aspects of environmental botany.
2. Ecosystem: Classification, general idea of different ecosystems.
3. Environment: concept of environment, environmental segments, Biosphere.
4. Biodegradable substances: Classification of pesticides, A brief history of use of synthetic pesticides, ecological effects of pesticide pollution, Bio-accumulation and biomagnifications of pesticide.

#### Unit – II

5. General idea about pollution, Pollutants.
6. Water pollution: Physico-chemical and biological characteristics of polluted and drinking water.
7. Air pollution :Air pollutants, PAN, Ozone, Ozone layer and Ozone hole ,Green house effects ; Consequences of climate change (global warming, Sea level rise).
8. Radioactive pollution: General ideas about hazardous impacts of radiations and radioactive fallouts.
9. Noise Pollution: General idea about various levels of noise pollution and human response.

#### Unit – III

10. Environmental management: Control of environmental pollution:
  - a. Water management of aquatic ecosystem.
  - b. Purification of water sewage treatment.
  - c. Air methods for monitoring air pollutants air quality management and air pollution control device, role of plants in air pollution abatement.
  - d. Soil conservation: Solid waste and their disposal, waste collection, reclamation and cycling processes.
  - e. Radioactive waste treatment.
  - f. Noise abatement.

#### Unit – IV

11. Conservation: Forest, Forestation, deforestation and social forestry.
12. Renewable energy sources.
13. Non – conventional energy sources.
14. Environmental education in India , international summits and treaties related to environment.
15. Control of environmental pollution through law.
16. Phytogeography: Distribution patterns, barriers and Age area hypothesis , vegetation & floristic regions of India.

#### Internal Assessment

25

1. Short test/ Quiz 10
2. Long Test 15

## SEMESTER -IV

### Paper –IVB

#### BOT404B: ADVANCED PLANT PHYSIOLOGY

MM. 75+25=100

#### Unit-I

##### Plant Metabolism

1. Photosynthesis and chemosynthesis:
  - a. Quantasomes, biosynthesis of chlorophylls, heme compounds, role and biosynthesis of accessory pigments, photo oxidation.
  - b. Biochemical pathways of conversion of solar energy into chemical energy and its utilization in CO<sub>2</sub> reduction cycle.
  - c. Efficient and inefficient plants, bacterial photosynthesis and its utility in nature.
2. Organic acid metabolism: Succulents, CAM pathway and its significance.
3. Plant Energetics : As controlled by photosynthesis, respiration and photorespiration
4. Respiration: Biological oxidation of carbohydrates and interconversions of the products, terminal oxidation, electron transport, role of cytochromes and other heme compounds.

#### Unit-II:

5. Nitrogen metabolism:

Synthesis and activation of amino acids, transcription and translation of genetic code, the template. Chemical regulation and biosynthesis of proteins and enzymes. Biochemistry of biological nitrogen fixation and its significance.
6. Phosphorus metabolism: Metabolism of phosphorylated compounds and their role.
7. Lipid metabolism: Classification of fat and fatty Acids, biosynthesis and breakdown of fats and lipids, its significance. Unsaturated fatty acids.
8. Vitamins : Water and fat-soluble vitamins, biochemical function of thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxin, biotin, folic acid, vitamin B12, ascorbic acid, vitamin A and vitamin D.

#### Unit-III

9. Secondary metabolites :
  - a. Coumarins and lignins : Structure and synthesis.
  - b. Tannins : Distribution synthesis and function.
  - c. Flavonoids and water-soluble pigments: Synthesis and function.
  - d. Hallucinogens: Distribution, chemistry and function.
  - e. Alkaloids : Pyrrole, pyrrolidine, pyridine, polyacetyl isoquinoline, tropane and indole alkaloids- their distribution, synthesis and function.
  - f. Saponins and sapogenins : Sterols, steroids, steroidal alkaloids - their distribution, synthesis and function.

#### Growth

10. Plant growth regulators: Natural and synthetic, biochemistry and physiological effects of auxins, gibberellins, cytokinins, brassinosteroids, jasmonic acid; salicylic acid, polyamines, morphactins and cyanogenic compounds.

#### Unit-IV

11. Stress physiology : Plant responses to biotic and abiotic stresses, mechanism of biotic and abiotic stress resistance, plant defence mechanisms against water stress, salinity stress, metal toxicity, freezing and heat stress and oxidative stress.
12. Photobiology: Photoreceptors, Phytochrome : history, discovery, physiological properties, interaction between hormones, and phytochrome, role of different phytochromes in plant development and flowering, mechanism of phytochrome signal transduction. Cryptochromes and phototropins.
13. Circadian rhythms in plants: Nature of oscillator, rhythmic outputs, entrainments (inputs) and adaptive significance.
14. Flower Initiation and Floral Expression

#### Internal Assessment

25

1. Short test/ Quiz 10
2. Long Test 15

**SEMESTER –IV**  
**Paper –IVC**

**BOT 404C: PLANT PATHOLOGY**

**MM. 75+25=100**

**Unit-I: Principles of Phytopathology**

1. Historical development and present status of Phytopathology.
2. Classification of plant diseases
3. General symptoms of plant diseases caused by fungi, bacteria and virus.
4. Concept of disease, Koch's postulates.
5. Mode of infection and development of pathogen in plants.
6. Role of enzymes and toxins in pathogenesis.

**Unit-II**

8. Defence mechanism in host, effect of infection on host physiology.
9. Dissemination of phytopathogens, plant disease forecasting and management.
10. Principle methods of plant disease control: Regulatory, cultural and biological, physical, chemical methods, resistant varieties.
11. Mycotoxins and storage diseases.
12. Integrated pest management.

**Unit-III:**

13. Epidemiology, symptoms, etiology, perennation and control of following diseases:
14. Diseases caused by Fungal Pathogens:  
Fruit and stem rot of papaya, Red rot of sugarcane, Damping off of seedling of crop plants, Downy mildew of bajra, crucifer and pea, Powdery mildew of barley and cucurbits, Rust of linseed, Cover and loose smut of barley, Wilt of Arhar, Leaf spot of crucifer, rice and turmeric, Blast of rice, Late blight of potato, Stem gall of coriander, Peach leaf curl, Tikka disease of groundnut.

**Unit-IV**

15. Diseases caused by nematodes: Ear cockle of wheat, Root knot of vegetables.
16. Abiotic/Non pathogenic diseases: Black tip of mango, Black heart of potato.
17. Disease caused by plant bacteria: Citrus canker, Blight of rice, Tundu disease of wheat, \_ Soft rot of carrot/onion.
18. Disease caused by plant viruses:  
Mosaic of apple, papaya, tobacco and potato; Leaf curl of tobacco, chilly and tomato; Tungro of paddy; Yellow vein of mosaic; Bunchy top of banana.
19. Disease caused by plant MLO: Sesame phyllody, Little leaf of brinjal, Grassy shoot of sugarcane.

**Internal Assessment**

**25**

- |                     |    |
|---------------------|----|
| 1. Short test/ Quiz | 10 |
| 2. Long Test        | 15 |

## M. Sc. IV SEMESTER PRACTICAL

### Paper I- Anatomy, Embryology and Morphogenesis

1. Study of the plants and its parts (root, stem and leaves) by sectioning and staining
2. Prepare of smear for the study of gametophyte
3. Micro- dissection techniques for embryo and embryo sac
4. Elementary techniques for pollen germination
5. Study for various stages in reproduction from permanent slides, pre and post fertilization in embryo sac

### Paper II- Biotechnology

1. Preparation of MS (Murashige and Skoog) basal medium for tissue culture
2. Preparation of medium for regeneration of *Bryophyllum*
3. To prepare medium for Anther culture *Datura innoxia* using IAA, MS medium

### Paper III- Molecular Biology and Biological Techniques

1. Study of permanent slides of chromosomes and special chromosomes (Lampbrush, Polytene and B-chromosome)
2. Study of banding pattern of DNA by electrophoresis
3. Karyotypic studies- Preparation of mitotic metaphase plates and to draw Camera Lucida drawing of chromosome and study of chromosome morphology Calculation of arm ratios, chromosome formula and symmetry of karyotype, preparation of idiograms and drawing photograph.
4. Preparation of various stains- Safranin, Fast green, Hematoxylin and Carmine
5. Study of fixation of botanical materials
6. Method for preparation of permanent slides- section cutting by the use of Microtome
7. To study the use of ocular and stage micrometers for the measurement of pollen grains and stomata
8. To extract and to detect nucleic acid from cauliflower or any floral tissue: (i) DNA by Diphenylamine test, (ii) RNA by Orcinol test
9. Isolation and purification of DNA from various sample using Agarose gel electrophoresis
10. Use of spectrophotometer in biochemical estimations- chloroplastic pigments, proteins, carbohydrates etc.
12. Demonstration of instruments: Gel Electrophoresis, Microtome , pH meter, oven, incubator, autoclave and centrifuge.

### Paper IV- Special Papers

#### IV A-Environmental Botany

1. Physico chemical analysis of polluted water- colour, acidity, alkalinity, taste, turbidity, total solids, total dissolved solids, conductivity, hardness, pH, Biological oxygen demand, Dissolved oxygen, Chemical oxygen demand
2. Biological examinations of polluted water- microscopic and culturing method (Density count)
3. Physico chemical analysis of polluted soil, pH, Electric conductivity, soluble cations and anions, heavy metals (base deficiency)
4. To analyze distribution pattern of selected species in an ecosystem
5. To measure the photosynthetic rate (A) and the specific leaf area of five tree species and observe relation between them.

**OR**

**IV B-Advanced Plant Physiology**

1. To extract the pigment from green leaf and to estimate quantitatively the percentage of Chl a, Chl b and total chlorophyll and the carotenoids spectrophotometrically
2. Estimate the percentage of total free amino acids in any plant material spectrophotometrically by using Ninhydrin
3. To estimate the amount of Total Nitrogen in dry leaves by Micro- Kjeldahl method
4. To estimate total protein of fresh moong, bean seedlings by biuret reagent
5. To estimate the percentage of soluble protein of fresh moong, bean seedling by Lowry's Method
6. To estimate the percentage of reducing sugar in any plant material by Somogy- Nelson's Method
7. To estimate the percentage of total soluble sugar in plant tissue using anthrone reagent
8. To estimate ascorbic acid in plant tissue
9. To measure the activity of amylase in germinating barley and moong seeds and to study the effect of :  
(i) substrate concentration, (ii) pH, (iii) Temperature, and (iv) any Heavy metal on amylase activity
10. To study the effect of any stress (temperature, water) on germination in barley seed
11. To estimate the percentage of fatty acid in castor, bean, mustard by Soxhlet's extraction method
12. To test the presence of fatty acid in castor seed
13. To measure the activity of the enzyme nitrate reductase (NR) in the leaves of *Vigna mungo* and to study the effect of : (1) substrate concentration, and (2) pH, on enzyme activity
14. To study the effect of various Plant Growth Regulators (IAA, GA<sub>3</sub>, Kinetin, Auxins and polyamines) on germination of bean seeds
15. To study the effect of GA<sub>3</sub> on flower initiation and expression in any plant
16. To study the phenomenon of Apical Dominance in Coleus and Tulsi
17. To study the phenomenon of Phototropism in plants
18. To study the phenomenon of Geotropism in plants

**OR**

**IV C-Plant Pathology**

1. A study of symptomology, histopathology, and identification of pathogen of various fungal diseases: Fruit and stem rot of Papaya, Red rot of sugarcane, Damping off of seedling of crop plants, Downy mildew of bajra, crucifer and pea, Powdery mildew of barley and cucurbits, Rust of linseed, Cover and loose smut of barley, Wilt of Arhar, Leaf spot of crucifer, rice and turmeric, Blast of rice, Late blight of potato, Peach leaf curl, Ergot of bajra, Tikka disease of ground nut
2. A study of symptomology in bacterial (Citrus canker, Blight of rice, Tundu disease of wheat, Soft rot of carrot/ onion), viral (Mosaic of apple, papaya, tobacco and potato, Leaf curl of tobacco, chilly and tomato, Tungro of paddy, Yellow vein mosaic and Bunchy top of banana) and M.L.O. (Sesame phyllody, Little leaf of brinjal, and Grassy shoot of sugarcane) disease
3. Preparation of culture media and sterilization
4. Isolation of fungi and bacteria from diseased plant
5. Inoculation experiment with fungal and bacterial plant pathogens
6. Measurement of fungal spores
7. Transmission experiments (mechanical and insect transmission) of plant virus
8. Use of fungicides and plant protection appliances
9. Field collection of 50 diseased plant specimens (fungal, viral and bacterial)

## M. Sc. SEMESTER-IV

### Book References

#### Paper I- Anatomy, Embryology and Morphogenesis

1. Esau, K. (2006). Anatomy of Seed Plants. Wiley
2. Roy, P. (2010). Plant Anatomy. New Central book Agency, New Delhi.
3. Pandey, B.P. (2001). Plant Anatomy. S.Chand & Company Ltd. New Delhi.
4. Cutler, D.F., Botha, T. & Stevenson, D.W. (2008). Plant Anatomy: An Applied Approach. John Wiley & Sons
5. Dwivedi, J.N. & Singh, R.B. (1986). Anatomy of Angiosperms. Central book Depot, Allahabad.
6. Bhojwani, S.S., Bhatnagar, S.P. & Dantu, P.K. (2014). The Embryology of Angiosperm. Vikas Publishing House Pvt. Ltd., New Delhi.
7. Sharma, H.P. (2009) Plant Embryology: Classical and Experimental. Narosa Publishing house, New Delhi
5. Wardlaw, C.W. (1968). Morphogenesis in Plants: A Contemporary Study. University of Manchester, Methuln and Company Ltd., London.
6. Sinnott, E.W. (1960). Plant Morphogenesis. McGraw Hill Book Company, London.
7. Cutter, E.G. (1966). Trends in Plant Morphogenesis. Longmans, London.

#### Paper II- Biotechnology and Tissue Culture

1. Govil, C.M., Aggarwal, A. & Sharma, J. (2017). Plant Biotechnology and Genetic Engineering. PHI Learning Pvt Ltd, Delhi.
2. Bhojwani, S.S. & Razdan, M.K. (1996). Plant tissue Culture: Theory and Practice. Elsevier Science Publisher, New York.
3. Slater, a., Scott, N. & Fowler, M. (2010). Plant biotechnology: The Genetic manipulation of Plants. Oxford University Press, oxford.
4. Dube, R.C. (2014). A Text Book of Biotechnology. S. Chand & Company Ltd., New Delhi
5. Singh, B.D. (2012). Biotechnology. Kalyani Publishers, New Delhi.
6. Gupta, P.K. (2016). Plant Biotechnology. Rastogi Publications, Meerut.
7. Chawla, H.S. (2006). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., N. Delhi.
8. Kumaresan, V. & Arumugam, N. (2016). Fundamentals of Biotechnology. Saras Publication, Kanyakumari.
9. Janarthanan, S. & Vincent, S. (2009). Practical Biotechnology. Universities Press, Hyderabad.

#### Paper III- MOLECULAR BIOLOGY AND BIOLOGICAL TECHNIQUES

1. Sheeler, P. & Bianchi, D.E. (2009). Cell and Molecular Biology. Wiley
2. Rastogi, S.C. (2010). Molecular Biology of the Cell. New Age International publisher, New Delhi.
3. Gupta, P.K. (2014). Cell and Molecular Biology. Rastogi Publications, Meerut.
4. Gupta, P.K. (2005). Molecular Biology and Genetic engineering. Rastogi Publications, Meerut.
5. Vidyavathi, N. & Chetan, D.M. (2009). Molecular biology. I.K. International Publishing House Pvt. Ltd., New Delhi.
6. De Robertis, E.D.P. & De Robertis, Jr. E.M.F. (1987). Cell and Molecular biology. Lea and Febiger, U. S.
7. Raghava, N. & Raghava, R.P. (2017). Biophysical methods: Tools and Techniques in Biology. Part I- Microscopy. Scholarink.com/Notion Press Media Pvt. Ltd, Chennai, TN.
8. Prasad, M.K. & Prasad, M.K. (1984). Outlines of Microtechnique. Emkay Publications, Delhi.
9. Patki, L.R., Bhalchandra, B.L. & Sapkal, V.M. (1983). An Introduction to Microtechnique. S.Chand & Company Ltd., New Delhi.
10. Dwivedi, J.N. & Singh, R.B. (1990). Essentials of Plant Techniques. Scientific Publishers, Jodhpur.
11. Yadav, P.R. & Tyagi, R. (2006). Biological Techniques. Discovery Publishing House, New Delhi.
12. Ghatak, K.L. (2011). Techniques and Methods in Biology. PHI Learning Pvt. Ltd., New Delhi.
13. Wilson, K. & Walker, J. (2013). Principles and Techniques of Biochemistry and Molecular biology. Cambridge University Press, London.

## **Paper IV- Special Papers**

### **IV A-Environmental Botany**

1. Odum,E.(1971). Fundamentals of Ecology. Saunders,Philadelphia
2. Odum, E., Barrick, M. & Barrett, G.W. (2005). Fundamentals of Ecology. Cengage Publishers (India Edition)
3. Chapman, J.L. & Reiss, M.J. (2003). Ecology: Principles and Applications. Cambridge University Press, London
4. Sharma,P.D.(2017).Ecology and Environment. Rastogi Publications, Meerut
5. Siddhartha,K.(2013). Ecology and Environment. Kisalaya Publoications, New Delhi
6. Sharma,P.D.(2015).Environmental Botany and Plant Pathology.Rastogi Publications,Meerut.
7. Verma,V.(2011).Plant Ecology.Ane Books Pvt.Ltd.,New Delhi.
8. Ambasht,R.S.& Ambasht,N.K.(2008).A Text Book of Plant Ecology.CBS Publishers,Ltd,N.Delhi.
9. Kumaresan,V.& Arumugam,N.(2016).Plant Ecology and Phytogeography.Saras Publications,kanyakumari.
10. Kapur,P.& Govil,S.R.(2004).Experimental Plant Ecology.CBS Publishers Pvt Ltd.,New Delhi.

### **Paper IV B- Advanced Plant Physiology**

1. Datta,S.C.(2010).Plant Physiology.New Age International Publishers,New Delhi.
2. Stiles,W.(2016).Principles of Plant Physiology.Discovery Publishing House,New Delhi.
- 3.Tivedi,P.C.(2006). Advances in Plant Physiology.I.K.International Publishing House Pvt Ltd,New Delhi.
- 4.Sinha,R.K.(2015). Modern Plant Physiology.NarosaPublishing House,New Delhi.
5. Wilkins,M.B.(1984).Advanced Plant Physiology,Longman,London.
6. Oxlade,E.(2010).Plant Physiology.The Structure of Plants Explained.Viva Books,New Delhi.
- 7.Dhaka,T.S.,Singh,L.& Kumar,A.(2015).Plant Physiology.Pragati Prakashan,Meerut.
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- 9.Inam,A.(2012).A Laboratory Manual of Plant Physiology, Biochemistry and Ecology.Agrobios(India),Jodhpur.
- 10.Kochhar,S.L. & Gujral,S.K.(2012). Comprehensive Practical Plant Physiology.MACMILLAN Publisher India Ltd,Delhi.
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- 13.Leopold,A.C. & Kriedemann,P.E.(1985).Plant Growth and Development.Tata McGraw-Hill Publishing Co,Ltd.,New Delhi.
- 14.Wilkins,M.B.(1979).The Physiology of Plant Growth and Development.Tata McGraw\_Hill Publishing Co.Ltd.,New Delhi.

### **IV C-Plant Pathology**

- 1.Agrios,G.N.(2005).Plant Pathology.Academic Press,London.
2. Singh,R.S.(2009).Introduction to Principles of Plant Pathology.Oxford & IBH,New Delhi.
- 3.Pandey,B.P.(1982).Plant Pathology.S.Chand & Company Ltd.,New delhi.
- 4.Srinivas,P.(2014).Plant Pathology at a Glance.New Vishal Publications,New Delhi.
- 5.Vidyasekharan,P.(2010).Principles of Plant Pathology.CBS Publishers & Distributors,New Delhi.
- 6.Bhattacharyya,U.K.(2017).Plant Pathology At A Glance.Kalyani Publishers,New Delhi.
- 7.Mehrotra,R.S.& Aggarwal,A.(2017).Plant Pathology.McGraw-Hill Education,New Delhi.
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