

**RADHA GOVIND UNIVERSITY
RAMGARH, JHARKHAND**

DEPARTMENT OF BOTANY



**CHOICE BASED CREDIT SYSTEM CURRICULUM
FOR M.Sc. BOTANY PROGRAMME
SUBJECT CODE = 16**

**FOR POST GRADUATE COURSES UNDER
RADHA GOVIND UNIVERSITY**

Implemented w.e.f.
Academic Session 2025-2026 & onwards

Syllabus for M.Sc. (Botany) Examination in Choice Based Credit System (CBCS)

The M.Sc. (Botany) course shall consist of four Semesters, each Semester of six month duration, as detailed in the University Regulation. The course structure will be as follows:

Semester-I

- 1st Paper (Theory) : BOT F01 -Foundation
- 2nd Paper (Theory) : BOT C02 - Core Course 1
- 3rd Paper (Theory) : BOT C03 - Core Course 2
- 4th Paper (Practical) : BOT C04 - Practical based on Papers 2nd & 3rd Papers.

Semester-II

- 5th Paper (Theory) : BOT S05 - Skill Development
- 6th Paper (Theory) : BOT C06 - Core Course 3
- 7th Paper (Theory) : BOT C07 - Core Course 4
- 8th Paper (Practical) : BOT C08 - Practical based on 6th & 7th Papers.

Semester-III

- 9th Paper (Theory) : BOT A09 - Generic Elective (Open Elective)
- 10th Paper (Theory) : BOT C10 - Core Course 5
- 11th Paper (Theory) : BOT C11 - Core Course 6
- 12th Paper (Practical) : BOT C12 - Practical based on 10th & 11th Papers.

Semester-IV

Elective A: Cytogenetics and Crop Improvement

- 13th Paper (Theory) : BOT E13 - Elective Theory
- 14th Paper (Theory) : BOT E14 -Elective Theory
- 15th Paper (Practical) : BOT E15 -Practical based on 13th & 14th Papers.
- 16nd Paper (Practical) : BOT E16 -Project

Semester-IV

Elective B: Applied Ecology and Environmental Biotechnology

- 13th Paper (Theory) : BOT E13 - Elective Theory
- 14th Paper (Theory) : BOT E14 -Elective Theory
- 15th Paper (Practical) : BOT E15 -Practical based on 13th & 14th Papers.

- 16nd Paper (Practical) : BOT E16 -Project

Semester-IV

Elective C: Plant Biotechnology

- 13th Paper (Theory) : BOT E13 - Elective Theory
- 14th Paper (Theory) : BOT E14 -Elective Theory
- 15th Paper (Practical): BOT E15 -Practical based on 13th & 14th Papers.
- 16nd Paper (Practical) : BOT E16 -Project

M.Sc. (BOTANY)

The Course Structure of Semester I to IV shall be as under:

First Semester

Paper	Subject code	Nature of the course	No. of Credits	Teaching (in hours) per week	Minimum Teaching required (in hours)	Full Marks (I+E)
I	BOT F01	Foundation	5	5	60	100 (30+70)
II	BOT C02	Core	5	5	60	100 (30+70)
III	BOT C03	Core	5	5	60	100 (30+70)
IV	BOT C04	Practical (based on paper II & III)	5	5	60/120	100 (30+70)

2nd Semester

Paper	Subject code	Nature of the course	No. of Credits	Teaching (in hours) per week	Minimum Teaching required (in hours)	Full Marks (I+E)
V	BOT S05*	Skill Development/Practical	5	5	60	Theory (15+35=50) Practical (15+35=50)
VI	BOT C06	Core	5	5	60	100 (30+70)
VII	BOT C07	Core	5	5	60	100 (30+70)
VIII	BOT C08	Practical (based on paper VI & VII)	5	5	60/120	100 (30+70)

*= Theory paper will be of 50 marks and practical paper of 50 marks.

3rd Semester

Paper	Subject code	Nature of the Course	No. of Credits	Teaching (in hours) per week	Minimum Teaching required (in hours)	Full Marks (I+E)
IX	BOT A09*	Open Elective/Practical	5	5	60	Theory (15+35=50) Practical (15+35=50)
X	BOT C10	Core	5	5	60	100 (30+70)
XI	BOT C11	Core	5	5	60	100 (30+70)
XII	BOT C12	Practical (based on paper X & XI)	5	5	60/120	100 (30+70)

*= Theory paper will be of 50 marks and practical paper of 50 marks.

4th Semester

Paper	Subject code	Nature of the course	No. of Credits	Teaching (in hours) per week	Minimum Teaching required (in hours)	Full Marks (I+E)
XIII	BOT E13	Elective Theory	5	5	60	100 (30+70)
XIV	BOT E14	Elective Theory	5	5	60	100 (30+70)
XV	BOT E 15	Elective Practical (based on paper XIII & XIV)	5	5	60	100 (30+70)
XVI	BOT E16	Dissertation/Project	5	5	60/120	100

SEMESTER -I

**Paper-I
BOT F01
Foundation Course**

Credits: 05

Full Marks: 70

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Structure and evolutionary relationship of Prokaryote, Mesokaryote and Eukaryote
- 2) Salient features and life cycle patterns in algae.
- 3) Salient features and life cycle patterns in fungi.
- 4) Salient features and life cycle patterns in Bryophytes.
- 5) Salient features and life cycle patterns of Pteridophytes.
- 6) Salient features and distribution of Gymnosperms.
- 7) International Code of Botanical Nomenclature (ICBN): History of ICBN, principles, rules, types method, author citation, valid and effective publication, principle of priority, retention, rejection, and choice of names, proposed bio code and phylocodes.
- 8) Herbarium: Brief account of herbarium, process of preparation of herbarium, botanical gardens of India and the world; Documentation: Flora, Keys: single access and multi-access.
- 9) Economic Botany- Medicinal, timber yielding and oil yielding plants and Underutilized Cereals (Millets) in Jharkhand.

Suggested Readings:

1. Botany for Degree Students Algae by Vashishta B.R.
2. College Botany: 1: Including Alge, Fungi, Lichens, Bacteria, Viruses, Plant Pathology, Industrial Microbiology and Bryophyta by Pandey B.P.
3. An Introduction to Pteridophyta by A. Rashid.

Paper-II BOT C02

Core Course-I

Microbiology, Mycology, Phycology and Plant Pathology

Credits: 05

Full Marks: 70

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Bacteria: Reproduction in Bacteria-Binary Fission, Recombination-Conjugation, Transformation and Transduction. Economic importance of bacteria with special reference to agriculture, industry and medicine.
- 2) Cyanobacteria : Characteristic features, Range of Vegetative Structure, Ultra-Structure of a typical Cyanobacterial Cell, Reproduction and Cyanobacteria as biofertilizer and their role in environmental management.
- 3) Virus:- Nomenclature and classification, distinctive properties of virus, morphology and ultra structure, Virus related agents (Viriods and Prions). Viral replication: lytic and lysogenic.
- 4) Mycoplasma : Structure, life cycle and significance.
- 5) Classification of Fungi (Alexopoulos and Mims. 1979), Structure, life cycle and phylogeny of Chytridiales, Erysiphales, Uredinales, Moniliales; General account of Mycotoxin, mycorrhizae and heterothallism; Fungi as biocontrol agents.
- 6) Algae:- Role of pigments, reserve food and flagella in the Classification of algae, Structure, life cycle and phylogeny of Chaetophorales, Charales and Fucales; Evolution of sex in algae; Economic Importance of Algae with special reference to Algal bloom, biofertilizers and indicator of water pollution.
- 7) Symptoms, etiology and control measures of the following diseases:
 - (i) Bacterial leaf blight of paddy

- (ii) Leaf curl of papaya
- (iii) Little leaf of brinjal.
- (iv) Rust of linseed
- (v) Tikka disease of groundnut

Suggested Readings:

1. Textbook of Microbiology by Kanika Sharma
2. Advance Studies In General Microbiology (3 Vols) by Joshi D
3. Botany For Degree Students – Fungi by Vashishta B.R. and Sinha A.K.
4. Plant Pathology- Pathogen and plant disease by Dr. B.P. Pandey (S.Chand).
5. Pelczar, JM, Chan, ECS and Krieg, MR. 1993. Microbiology. Tata McGraw Hill.

Paper III
BOT C03
Core Course-II
Bryophyta, Pteridophyta, Gymnosperms

Credits: 05

Full Marks: 70

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Bryophytes:** Structure, reproduction, affinities and evolutionary trends of the following orders- Sphaerocarpales, Takakiales, Anthocerotales, Sphagnales; Evolution of gametophytes and sporophytes in bryophytes; Fossil bryophytes.
- 2) Pteridophytes:** Classification of Pteridophytes (Smith 1955, Sporne 1975) ; Telome theory; its merits and weaknesses ; Stelar organization and evolution of stele in pteridophytes ; Heterospory and seed habit in pteridophytes; Economic importance of Pteridophytes; Structure, reproduction, affinities and evolutionary trends of the following orders:Psilophytales, Psilotales, Lepidodendrales, Ophioglossales, Marsiliales
- 3) Gymnosperm:** Classification of Gymnosperm (Sporne 1965); Structure, reproduction, affinities and evolutionary trends of Pentoxytales, Cordaitales, Ginkgoales, Taxales, Gnetales (emphasis on angiospermic features) ; Evolution of female gametophytes and Embryogeny in gymnosperms; Distribution of Living and fossil Gymnosperms with special reference to Jharkhand.

Suggested Readings:

1. College Botany: 1: Including Alge, Fungi, Lichens, Bacteria, Viruses, Plant Pathology, Industrial Microbiology And Bryophyta by Pandey B.P.
2. Pteridophyta by Sharma O P
3. The Morphology of Gymnosperms by Sporne R. K. and Sporne R. Kenneth
4. Gymnosperms by S.P. Bhatnagar.
5. Rashid, A, 2011, An Introduction to Pteridophyta, 2nd edition, (Reprint), Pub. Vikas Publishing House Pvt. Ltd., Noida.

Paper-IV : Practical Paper
BOT C04
Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Identification of the members of different Groups of algae.
- 2) Study and identification of the genera of different Groups of fungi.
- 3) Study of general habit, external and internal morphology of vegetative and reproductive features of the bryophytes.
- 4) Study of general habit, external and internal morphology of vegetative and reproductive features of the members of different groups of pteridophytes.
- 5) Study of general habit, external and internal morphology with special reference to their male and female reproductive structures of the members of different group of gymnosperms.
- 6) Spotting; related to Microbiology, Phycology, Mycology, Bryophyta, Pteridophyta, Gymnosperms and fossils.
- 7) General overview of plant diseases.
- 8) Viva-voce
- 9) Practical records, field reports, herbarium, charts, models etc.

SEMESTER -II

Paper-V
BOT S05
Skill Development
BIOFERTILIZERS

Credits: 05
(Theory 50+ Practical 50)

Full Marks: 100

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) General account about the microbes used as biofertilizer – *Rhizobium* – isolation, identification, mass multiplication, , Actinorrhizal symbiosis.
- 2) *Azospirillum*: isolation and mass multiplication – carrier based inoculants, associative effect of different microorganisms. *Azotobacter*, characteristics – crop response to *Azotobacter* 14nocolums, maintenance and mass multiplication.
- 3) Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.
- 4) Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and 14nocolums production of VAM, and itsinfluence on growth and yield of crop plants.
- 5) Organic farming – Green manuring and organic fertilizers, Recycling of bio-degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field application, wild and local varieties of crops.

PRACTICAL: Practical will be based on the topic of this paper.

Paper-V
Skill Development
BOT S05
MUSHROOM CULTIVATION
Credits: 05
(Theory 50+ Practical 50)

Full Marks: 100

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Introduction, history. Nutritional and medicinal value of edible mushrooms; poisonous mushrooms. Types of edible mushrooms available in India – *Volvariella volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*, Types of Edible mushroom of Jharkhand.
- 2) Cultivation Technology : Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation – paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation – Low cost technology, Composting technology in mushroom production.
- 3) Storage and nutrition : Short –term storage (Refrigeration – upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition – Proteins – amino acids, mineral elements nutrition – Carbohydrates, Crude fibre content – Vitamins.
- 4) Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio – Marketing in India and abroad, Export Value.
- 5) Role of Mushroom in socio economic development of Jharkhand.

PRACTICAL: Practical will be based on the topic of this paper.

Paper-VI
BOT C06
Core Course III
Cell biology, Genetics and Molecular Biology

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Structure organization and function of intracellular organelles- Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, glyoxysomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility. Plasmam membrane- Structure and Function- Mechanism of sorting and regulation of intracellular transport, Electrical properties of membrane.
- 2) Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycles, regulation and control of cell cycle).
- 3) Structure of chromatin and chromosomes; packaging of DNA; interrupted genes; gene families; unique and repetitive DNA; heterochromatin and euchromatin; banding patterns; transposable elements.
- 4) B-Chromosomes: Origin, structure and genetic significance.
- 5) Extra chromosomal inheritance: Inheritance of mitochondria and chloroplast genes; maternal inheritance.
- 6) Quantitative genetics: Polygenic inheritance (characteristic, multiple factor hypothesis, seed colour in wheat, corolla length in tobacco); heritability and its measurements; QTL-mapping.

- 7) Structural alteration in chromosomes: Origin, meiosis and breeding behavior of duplication, deficiency, inversion and translocation.
- 8) Numerical alterations in chromosomes: Origin, Occurrence, Production and meiosis of haploids, euploids and aneuploids; origin and production of autopolyploids; genome constitutions and analysis of allopolyploids; evolution of major crop plants; use of aneuploids in crop improvement.
- 9) Nuclear DNA content; C- value paradox; Cot-curve and its significance; restriction mapping – concept and technique.
- 10) DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extra chromosomal replicons, Telomeric DNA replication, DNA damage and repair mechanisms.
- 11) RNA synthesis and processing : Transcription factor and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, RNA splicing, polyadenylation, structure and functions of different types of RNA.
- 12) Regulation of gene expression in prokaryotes and eukaryotes.
- 13) Tools of genetic engineering: Restriction endonucleases; Gel electrophoresis; Ligases and Probes, Cloning Vectors: Plasmids, Cosmids, Phage vectors, BAC and YAC Vectors.
- 14) Nucleic Acid hybridization: Southern, Northern and Western blotting techniques.

Suggested Readings:

1. Cell Biology, Genetics, Evolution & Ecology (Multicolor Edition) by Verma P.S. and Agarwal V.K. (S. Chand).
2. PRINCIPLES OF MOLECULAR BIOLOGY, 2ND EDN by Veer Bala Rastogi.
3. Cell Biology and Genetics by P.K.Gupta.

Paper-VII

BOT C07

Core Course IV

Ecology and Environmental Biology

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

1) Ecosystem :

- a) Modern concept, structural components, trophic structure, food chain, food web and ecological pyramids.
- b) Ecological energetics: concept and mode of energy flow in aquatic ecosystem.
- c) Productivity: types and methods of primary productivity and its measurement.

2) Community:

- a) Structure: Analytic and synthetic characters with emphasis on I.V.I, and species diversity index (H).
- b) Ecological niche, edges and ecotones.
- c) Ecological succession: Types and process of succession, hydrosere and xerosere, concept of climax.

3) Plant Geography:

- a) Biomes of world
- b) Major vegetation types of India with special reference to Jharkhand
- c) Major floristic regions of India

4) 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.

Resource Ecology

- 5) Plant biodiversity: Concept, status in India, utilization and concerns.
- 6) Strategies for plant conservation:
 - (a) *In situ* conservation : Protected areas in India-sanctuaries, national parks, biosphere reserves,
 - (b) *Ex situ* conservation: Botanical gardens, gene banks, seed banks, cryobanks.
 - (c) Genetically modified (GM) crops
- 7) Climate change: Basic concept of climate change vis-a-vis global warming; present status and future projections of climate change; impact of climate change on agriculture; adaptation and mitigation of climate change.
- 8) Forest management:
 - a) Forest: forest types found in India, importance of forest, strategies for conservation and management of forest, with special reference to deforestation , Chipko movement, Social forestry and Biosphere reserves.
 - b) National forest policy and forest laws
- 9) Brief account of the following:
 - a) Bioindicators
 - b) Convention on Biological Diversity (CBD)
 - c) Kyoto protocol and carbon trading
 - d) IUCN (International Union for Conservation of Nature)
 - e) Gene campaign
 - f) Role of biotechnology :- pollution control & solid waste management

- g) Rare, threatened and endangered flora of India
- h) Wetlands, mangroves, sacred groves and coral reefs for conservation of wild biodiversity.

Suggested Readings:

1. Environmental Ecology, Biodiversity, Climate Change & Disaster Management for by Ravi P Agrahari.
2. Odum, E. P. and Barret G.W. 2005. Fundamentals of Ecology. Cengage publication
3. Odum, E.P., 1983. Basic Ecology., Saunders College Publishing
4. Singh, J.S., Singh S.P. and Gupta S.R. 2006. Ecology Environment and Resource Conservation. Anamaya Publishers

**Paper-VIII : Practical Paper
BOT C08**

Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Plant anatomy related to ecological adaptations.
- 2) To determine frequency /density/ abundance in a grassland vegetation.
- 3) Study of temperature, pH, transparency, dissolved O₂/free CO₂ from aquatic ecosystem.
- 4) Isolation of algae and bacteria from aquatic ecosystem.
- 5) Cytological techniques: Pre-fixation, fixation, mounting, squashing of root tips for the study of various stages of mitosis.
- 6) Study of different stages of meiosis.
- 7) Problems based on Mendelian ratios and their modifications, statistical analysis and genetic explanation
- 8) Spotting related to Theory papers VI & VII.
- 9) Viva-voce.
- 10) Practical records, field reports, herbarium, charts, models etc.

SEMESTER-III

Paper-IX
BOT A09
Generic (Open) Elective

PLANTS AND HUMAN WELFARE

(Credits: 05)
(Theory 50 + Practical 50)

Full Marks: 50

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

UNIT 1: Utility of Plants in relation to human beings, General introduction & its objectives.

UNIT 2: Common name, scientific name, methods of Cultivation and Production and uses of the following-

Cereals – Rice, Wheat, Maize

Pulses- Arhar, Moong, Lentil, Gram.

UNIT 3: Common name, scientific name, cultivation, along with the role of climatic factors and uses of the following-

Fibres- Cotton , Jute

Wood- Sal, Teak, Shisham

UNIT 4: Common name, scientific name, cultivation and uses of following-

Spices- Clove, Black peeper, Saffron, Coriander.

Medicinal plants- Neem, Amla, Tulsi, Turmeric, Garlic.

PRACTICAL: Practical based on topics of this paper.

**Paper-IX
BOT A09**

Generic Elective

1. BIODIVERSITY (Microbes, Algae, Fungi and Archegoniatae)
(Credits: 05)
(Theory 50 + Practical 50)

Full Marks: 50

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Microbes

Viruses – Discovery, general structure; Economic importance; Bacteria – Discovery, General characteristics and cell structure; Economic importance.

Algae and Fungi

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Economic importance of algae.

Introduction- General characteristics; Economic importance of fungi; Edible fungi.

Introduction to Archegoniatae

Unifying features of archegoniates, Transition to land habit, Alternation of generations.

Bryophytes

General characteristics, adaptations to land habit, Range of thallus organization. Ecology and economic importance of bryophytes.

Pteridophytes

General characteristics, classification, Early land vascular plants, Ecological and economical importance of Pteridophytes.

Gymnosperms

General characteristics, Ecological and economical importance.

PRACTICAL: Practical based on topics of paper biodiversity.

Paper-X
BOT C10
Core Course VI
Plant Physiology and Biochemistry

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Plant-Water relation

- 1) Water and mineral relation of plants : water potential and membrane transport system;
- 2) Role of macro - and micronutrients.
- 3) Uptake, transport and translocation of water and mineral salts from soil, through cells, mechanisms of loading and unloading of photoassimilates.
- 4) Mechanism of stomatal opening and closing

Biochemistry

- 1) Enzymes: Nomenclature and classification, nature and properties, coenzymes & prosthetic groups, Enzymes kinetics; mechanism and mode of enzyme action, isoenzymes, allosteric enzymes, ribozyme.
- 2) Composition, structure and function of biomolecules:
 - a) Carbohydrates
 - b) Lipids
 - c) Proteins (including secondary, tertiary & quaternary structure, domains)
 - d) Nucleic acids
 - e) Vitamins
- 3) Secondary metabolites: Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

Metabolism

- 4) Photosynthesis: Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO₂ fixation-C₃, C₄ and CAM pathways; photorespiration.
- 5) Respiration: Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.
- 9) Lipid metabolism: Biosynthesis of fatty acids, Glyoxylate cycle, α & β oxidation of lipids.
- 10) Nitrogen metabolism- Nitrate and ammonium assimilation, amino acid biosynthesis. .

Growth and Development

- 11) Phytohormones: Chemical nature, biosynthesis, mode of action and role of Auxins, Gibberellins, Cytokinins, ABA and Ethylene.
- 12) Sensory photobiology: Phytochromes, Cryptocromes; Photoperiodism; Vernalization and Biological clocks.
- 13) Stress Physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanism & resistance to biotic stress and tolerance to abiotic stress."
- 14) Senescence and Programmed Cell Death (PCD)

Suggested readings:

1. A Textbook Of Plant Physiology & Biochemistry by S K Verma and Mohit Verma
2. Fundamentals Of Plant Physiology by V. K. Jain
3. Taiz and Zeiger, 2010, Plant Physiology, 5th Edition , Sinurer Associates
4. Hopkins, W.G. and Huner N.P.A., 2009, Introduction to Plant Physiology, 4th Edition Wiley International Edition, John Wiley & Sons, USA

Paper-XI

BOT C11

Core Course VI

Taxonomy, Anatomy, Embryology and Plant Tissue Culture

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Taxonomy

- 1) Origin of angiosperms.
- 2) Systems of Angiospermic classification (Bentham and Hooker, Hutchinson, and Takhtajan)
- 3) Concepts of phytogeography: endemism, hot spots, plant exploration & plant introduction.
- 4) Recent trends in Taxonomy with special reference to Numerical taxonomy, chemotaxonomy, Cytotaxonomy and molecular taxonomy
- 5) Distinctive taxonomic features and economic importance of the following Angiospermic families: Apocynaceae, Asclepiadaceae, Lamiaceae, Verbenaceae, Euphorbiaceae, and Poaceae.

Anatomy

- 6) Organization of Shoot Apical Meristem (SAM); Leaf development and differentiation; Organization of Root Apical Meristem (RAM).
- 7) Stomata: Morphology and types.
- 8) Periderm : Formation and function; lenticels, Abscission and healing of wounds
- 9) Nodal anatomy and its significance.

Embryology

- 10) Male sterility; Self and Interspecific incompatibility.
- 11) Polyembryony: Classification, development, experimental induction, causes and practical value of polyembryony.
- 12) Apomixis : Types, diplospory, apospory, parthenogenetic development of embryo; causes; genetics and significance of apomixis.
- 13) Palynology: Pollen morphology, pollen wall features, germination of pollen grains, scope of palynology.

Plant Tissue Culture

- 14) History and present status of plant tissue culture, totipotency, organogenesis, embryogenesis
- 15) Micropropagation, protoplast culture and somatic hybridization, Somatic embryogenesis, Artificial seeds - their advantages and limitations.

Suggested readings:

1. Plant Anatomy by B.P. Pandey
2. Fundamentals Of Plant Physiology by V. K. Jain
3. The Embryology of Angiosperms, 6th Edition by S.P. Bhatnagar, P.K. Dantu,
4. Rastogi Publications ANATOMY AND EMBRYOLOGY OF NGIOSPERMS (B-32) by Dr. V. Singh, Dr. P.C. Pande
5. Plant Tissue Culture by Kalyan Kumar De
6. Introduction to Plant Cell, Tissue and Organ Culture by Purohit S.D

**Paper-XII : Practical Paper
BOT C12**

Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Anatomical study of the stem showing anomalous secondary growth.
- 2) Deposition of pollen grains on the stigma and development of pollen tubes through the style.
- 3) Study of different stages of the developing embryo.
- 4) Study and identification of tissue elements from the macerated stem.
- 5) Hybridization techniques.
- 6) Techniques of Inoculation of the explant to the nutrient medium.
- 7) Separation of chlorophyll pigments (Paper chromatography).
- 8) Description and identification of the local angiospermic plants.
- 9) Biochemical tests of Carbohydrates/Protein/Lipids.
- 10) Spotting related to Theory papers XI.
- 11) Viva-voce.
- 12) Practical records, field reports, herbarium, charts, models etc.

SEMESTER-IV

ELECTIVE THEORY

Paper-XIII

BOT E13

Elective Theory 'A'

Cytogenetics and Crop Improvement

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

CYTOGENETICS

- 1) Cell cycle: Interphase and mitosis, cytokinesis; stages of meiosis, significance of meiosis, synaptonemal complex and its significance in meiosis; recombination nodules and their role in meiotic recombination. Dynamics of Chromosome movement- events and mechanism.
- 2) DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms.
- 3) RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.
- 4) Physical basis of heredity : the nucleus (including new basket model of nuclear pore, complex, nucleocytoplasmic traffic); structure of chromatin fibre; special types of chromosomes (lampbrush, salivary gland and B chromosomes)
- 5) Fine structure of gene: at the genetic level: Gene Vs allele : a new concept of

allelomorphism (recombination, complementation, position effect, pseudoalleles, cis- trans effect); fine structure of gene (lozenes in *Drosophila*, r II in T4 phage); cistron, recombinant and mutation).

- 6) Regulation of gene expression: Operon circuits in bacteria and other prokaryotes; circuits for lytic cycle and lysogeny in bacteriophages; regulation of gene expression in eukaryotes (including cell signaling and cell receptors).

Plant Breeding

- 7) Inbreeding and heterosis: Effects of inbreeding; degrees of inbreeding depression; concept of heterosis and hybrid vigour; manifestation of heterosis; genetic basis of heterosis; exploitation of heterosis in self, cross and vegetatively propagated crops; fixation of heterosis.
- 8) Breeding for disease resistance: Concept of plant diseases; vertical and horizontal disease resistance; procedures for breeding disease resistant crops; achievements.
- 9) Ploidy breeding : Haploid breeding, use of autopolyploidy and allopolyploidy in crop improvement.
- 10) Mutation breeding : Use of the physical and chemical mutagens in induction of mutation; LD₅₀; procedure of mutation breeding ; advantages, disadvantages and limitations of mutation breeding; achievements made through mutation breeding.
- 11) **Allelopathy** Brief history; definition; Evidence of allelopathy, Allelochemicals – occurrence, mode of allelochemicals release, mode of action of allelochemicals. Interactions between plant communities – crop-crop interaction, crop-weed interaction. Exploitation of allelopathy in crop production and protection, future prospects.

Suggested readings:

1. Crop Improvement- II (Rabi Crops) by Dr. D.G. Ingole, Dr. S.S. Vitnor,
2. Plant Breeding at a Glance by Phundan Singh
3. PV A TEXTBOOK OF GENETICS [B.SC (N) 2ND YEAR STUDENTS]
BY S.S RANDHAWA
4. Clark, M.S. and Wall, W.J. 1996, Chromosomes : The Complex Code. Chapman & Hall, London.
5. Stebbins, G.L. 1950, Variation and Evolution in Plants. Columbia Univ. Press, New York.
6. Swanson, C. P., Mertz, T.F. and Young, W.J. Cytogenetics : The Chromosomes in Division, Inheritance and Evolution (2nd Edn). Englewood Cliff, Prentice-Hall, New Jersey

Paper-XIV
BOT E14
Elective Theory 'A'
Cytogenetics and Crop Improvement
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Plant Tissue Culture

- 1) Somatic embryogenesis: Introduction; sources for somatic embryogenesis; direct and indirect embryogenesis; protocol and the factors affecting somatic embryogenesis; significance; the artificial seeds.
- 2) Micropropagation : Introduction; protocol; sources; advantages.
- 3) Somatic hybridization: Objectives; protocol; selection of the fused protoplasts; chromosome status of the somatic hybrids; significance; cybrids.
- 4) Anther and Pollen culture: Objectives; protocols for anther and pollen culture; comparison between anther and pollen culture; screening of haploids; methods of diploidization; significance of anther and pollen culture.
- 5) Embryo culture, *In vitro* fertilization.

Recombinant DNA Technology

- 6) Tools of genetic engineering: The cloning vectors - plasmids, cosmids, phages, BAC and YAC vectors; restriction endonucleases; ligases; gel

electrophoresis; probes; Southern, Northern and Western blottings.

- 7) Polymerase Chain Reaction (PCR).
- 8) Method of gene transfer in plants: Vectors - mediated gene transfer; *Agrobacterium tumifaciens*, the natural genetic engineer; methods of direct transformations-electroporation, chemically stimulated DNA uptake, use of liposomes, microinjections, sonication, microprojectile gun method, laser microbeam, and silicon carbide fibers.
- 9) The transgenic plants : Objectives; method of obtaining transgenic plants; production of transgenic plants in monocots; the transgenic plants having herbicide resistance, insect resistance, altered fatty acid composition in *Brassica* oil, resistance against stresses, male sterility and fertility restoration, molecular farming, production of edible vaccines, plants with enhanced nitrogen fixing ability; release of GM plants to the environment.

Biostatistics

- 10) Analysis of quantitative and qualitative data, ANNOVA, Correlation, Regression Sampling parameter and statistic, sampling and non- sampling errors, sampling distribution (sampling distribution of mean, sampling distribution of proportion, student's 't'-test, chi square distribution, degree of freedom, standard error, central limit theorem, finite population correction, statistical inference

Suggested readings:

1. Sharma, A.K. and Sharma, Archana. 1985. Advances in Chromosome and Cell Genetics. Oxford & IBH Publishing Co., Calcutta.
2. Schnedl, W.. Banding patterns in chromosomes. In: International Review of Cytology (Suppl. 4).
3. Lewine, Benjamin, Jones and Bartlet, Genes X, Sudbury, Massachusetts
4. Gupta, P.K., Cytogenetics, Rastogi Publication, Meerut
5. Peter, D, Snustand and Simmons, M.J., John Wiley and Sons Inc.
6. Plant Biotechnology by B. D. Singh, Kalyani Publications.

**Paper-XV : Practical Paper
BOT E15**

Elective Theory 'A'

Cytogenetics and Crop Improvement

Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Method of preparing pre fixatives.
- 2) Method of preparing Acetocarmine, Fuelgen stains etc.
- 3) Squashing techniques.
- 4) Technique and method of permanent preparation of cytological materials.
- 5) Karyotype study of Metaphase chromosomes from root tips (*Allium cepa*, *Allium sativum*, *Vicia faba*, *Zea mays*, *Pisum sativum*, *Triticum aestivum* etc.).
- 6) Study of chromosomes of different stages of mitosis by squash technique.
- 7) Study of different stages of meiosis from the floral buds (*Allium cepa*; *Vicia faba*, *Zea mays*, *Pisum sativum*, *Triticum aestivum*, *Rhoeo discolor*, *Tradescantia* sp.).
- 8) Estimation of DNA by spectrophotometer.
- 9) Study of abnormalities in mitosis and meiosis.
- 10) Emasculation and hybridization techniques.
- 11) Study of chromocentres found in the stigmatic receptive cells of crucifers.

Paper-XIII
BOT E13
Elective Theory B
Applied Ecology and Environmental Biotechnology

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

General Ecology

1) Ecosystem :

- a) Modern concept, structural components, trophic structure, food chain, food web and ecological pyramids.
- b) Ecological energetics: concept and mode of energy flow in aquatic ecosystem.
- c) Productivity: types and methods of primary productivity and its measurement.

2) Community:

- a) Structure: Analytic and synthetic characters with emphasis on I.V.I, and species diversity index (H).
- b) Ecological niche, edges and ecotones.
- c) Ecological succession: Types and process of succession, hydrosere and xerosere, concept of climax.

3) Phytogeography:

- a) Biomes of world
- b) Major vegetation types of India with special reference to Jharkhand.

Resource Ecology

- 4) Natural resources:
 - a) Biodiversity-concept, importance and quantum of biodiversity.
 - b) Forest, wetland, mangroves, agriculture, fisheries and wild life resources of India.
- 5) Modern fuel and their environmental effect:
 - a) Methanogenic bacteria and biogas.
 - b) Conversion of sugar to ethanol.
 - c) Solar energy converters.
 - d) Petroplants.
- 6) Traditional knowledge and natural resources. Basic concept of traditional knowledge; traditional knowledge in management of biodiversity and water resources.
- 7) Microbial diversity:
 - a) Role of microbes in environment.
 - b) Microbes as biofertilizers.
 - c) Enrichment of ore by microbes (biohydrometallurgy, biobenefication, biosorption).
 - d) Microbial hydrogen production.
- 8) Wetlands: Definition, characteristic and productivity, major wetlands of India and their biotic resources.

Limnology

- 9) Introduction and History of Limnology.
- 10) Lentic and Lotic ecosystem, quality of drinking water, strategies for conservation of fresh water.

- 11) Physico-chemical Characteristic of lentic and lotic ecosystem - Temperature, pH, conductivity, dissolved oxygen and free CO₂. B.O.D and C.O.D, Total nitrogen, phosphorus, TDS (Total Dissolved Solid).
- 12) Biological diversity of aquatic ecosystem with special reference to Algae and Macrophytes.
- 13) Measurement of Primary Productivity in fresh water ecosystem.

Applied Ecology

- 14) Remote sensing : Basic concept and application in pollution management and natural resource management.
- 15) Environmental protection act, 1986 and forest protection act, 1980.
- 16) Sustainable development: Basic concept, principle and application.
- 17) Biomonitoring:
 - a) Concept of biomonitoring
 - b) Biomonitoring of water and air pollution.
 - c) Advantages of biomonitoring over conventional techniques.
- 18) A brief account of:
 - a) Biopiracy
 - b) Bioprospecting
 - c) Environmental economics
 - d) Village biodiversity register
 - e) Bioethics
- 19) Important treaties:
 - a) CBD (Convention on Biological Diversity)
 - b) Paris agreement
 - c) Kyoto protocol

Paper-XIV
BOT E14
Elective Theory 'B'
Applied Ecology and Environmental Biotechnology
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Pollution Ecology

- 11) Radiation pollution : Types and measurement of radiation, sources of radiation, impact of radiation on human health and its mode of action, strategy for control/ minimizing radiation
- 12) Climate change: Basic concept of climate change vis-a-vis global warming; present status and future projections of climate change; impact of climate change on agriculture, biodiversity and human health; adaptation and mitigation of climate change.
- 13) Solid waste management:
 - a) Source, generation and classification of solid waste.
 - b) Management and utilization of solid waste.
 - c) Fly ash and mine spoil and their management.
- 14) Air pollution:
 - a) Critical air pollutants and their Indian standard.
 - b) Air pollution due to coal mining.
 - c) Management of air pollution.
- 15) Depletion of water resources :

- a) Alarming situation of ground and surface resources.
- b) Rain water harvesting and recharging aquifers.
- c) Conservation and management of fresh water ecosystem.

Environmental Biotechnology

- 16) Concept of environmental biotechnology, its scope and achievement.
- 17) Thuringenesis toxin as natural pesticides.
- 18) Biotechnology for pollution abatement:
 - a) Bioscrubber b) Biofilter c) Biochips d) Biosensor
- 19) Bioremediation
 - a) Concept of bioremediation, hyperaccumulators.
 - b) Technology: phytoextraction, rhizofiltration, phytoestabilization, phytodegradation.
 - c) Bioremediation of polluted water, air and soil.
 - d) Advantages of bioremediation over conventional techniques.
- 20) Waste water treatment: Introduction, sources of water pollution; technology of waste water treatment-chemical and biological treatment.
- 21) Brief account of:
 - a) Vermitechnology.
 - b) Bioplastics.
 - c) Biomass from waste.

Conservation Ecology

- 22) Principles and strategies for plant conservation:
 - (a) *In situ* conservation : International effect and Indian initiatives; protected areas in India-sanctuaries, national parks, biosphere reserves, wetlands, mangroves, sacred groves and coral reefs for conservation of wild

biodiversity.

(b) *Ex situ* conservation : Gene banks, seed banks, cryobanks; General account of the activities of Botanical Survey of India (BSI); National Bureau of Plant Genetic Resources (NBPGR); Indian Council of Agriculture Research (ICAR); Council of Scientific and Industrial Research (CSIR); Central Institute of Medicinal and Aromatic Plants (CIMAP) and Department of Biotechnology (DBT) for conservation.

23) Local Environmental Problems and their Remedies

- a) Forest degradation
- b) Agrobiodiversity erosion.
- c) Deforestation
- d) Water depletion
- e) Anthropogenic activities and its impact on environment.

Biostatistics

24) Analysis of quantitative and qualitative data, ANNOVA, Correlation, Regression Sampling parameter and statistic, sampling and non- sampling errors, sampling distribution (sampling distribution of mean, sampling distribution of proportion, student's 't' test, chi square distribution, degree of freedom, standard error, central limit theorem, finite population correction, statistical inference

**Paper-XV: Practical Paper
BOT E15**

Elective Theory 'B'

Applied Ecology and Environmental Biotechnology

Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) To determine the chloride content of water.
- 2) Collection, identification of different biota of fresh water ecosystem.
- 3) To determine the abundance, IVI and species diversity index (H) of grassland vegetation.
- 4) To determine the BOD and COD of different types of water samples.
- 5) Isolation of algae, bacteria and fungi from aquatic ecosystem.
- 6) Preparation of bacterial specimen and stain it with gram stain.
- 7) To determine the productivity by Dark & Light Bottle method.
- 8) A sum based on-standard error, 't' test or Analysis of variance.
- 9) Isolation of VAM from soil samples.
- 10) Spotting related to Theory papers X & XI.
- 11) Viva-voce.
- 12) Practical records, chart, models etc.

Paper-XIII
BOT E13
Elective Theory ‘C’
Plant Molecular Biology and Biotechnology

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Molecules and their Interactions

- 1) Structure of atoms, molecules and chemical bonds.
- 2) Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction etc.).
- 3) Conformation of nucleic acids (A-, B-, Z-,DNA), t-RNA, micro-RNA).
- 4) Stability of protein and nucleic acid structures.

Fundamental Processes of Plant Genome

- 5) DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms.
- 6) RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.

7) Control of gene expression at transcription and translation level: Regulation of phages, viruses, prokaryotic and eukaryotic gene expression, role of chromatin in regulating gene expression and gene silencing.

Molecular methods

8) Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis.

9) DNA sequencing methods, strategies for genome sequencing, CRISPER-CAS technique of gene editing.

10) Polymerase Chain Reaction (PCR): Basic concept; comparison of gene cloning through vectors and PCR procedure; applications of PCR in site- directed mutagenesis, preparation of probes, DNA polymorphism, molecular mapping, mutation studies, confirmation of a transferred gene, sex determination at the embryonic stage, and DNA fingerprinting (RFLP, RAPD and AFLP techniques).

11) The gene banks : Objective, procedure of making cDNA library and its advantages; construction of the genomic library; ligation; packaging and implications; the chromosome specific library; method of screening cDNA and genomic libraries; significance of the gene banks.

Paper-XIV
BOT E14
Elective Theory 'C'
Plant Molecular Biology and Biotechnology
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Plant Tissue Culture

- 1) Introduction- Totipotency, the culture environment, plant cell culture medium, plant growth regulators
- 2) Culture types- callus, cell suspension culture.
- 3) Somatic embryogenesis: Introduction; sources for somatic embryogenesis; direct and indirect embryogenesis; protocol and the factors affecting somatic embryogenesis; significance; the artificial seeds.
- 4) Somaclonal variations: Introduction; causes of Somaclonal variations; method for the screening of Somaclonal variants; achievements.
- 5) Micropropagation : Introduction; protocol; sources; advantages.
- 6) Somatic hybridization: Objectives; protocol; selection of the fused protoplasts; chromosome status of the somatic hybrids; significance; cybrids.
- 7) Anther and Pollen culture: Objectives; protocols for anther and pollen culture; comparison between anther and pollen culture; screening of haploids; methods of diploidization; significance of anther and pollen culture.
- 8) Techniques for plant transformation- *Agrobacterium* mediated gene transfer, the

biology of *Agrobacterium*, the Ti plasmid.

Applied Biology

- 9) Method of gene transfer in plants: Vectors - mediated gene transfer; *Agrobacterium tumifaciens*, the natural genetic engineer; methods of direct transformations-electroporation, chemically stimulated DNA uptake, use of liposomes, microinjections, sonication, microprojectile gun method, laser microbeam, and silicon carbide fibers.
- 10) The transgenic plants : Objectives; method of obtaining transgenic plants; production of transgenic plants in monocots; the transgenic plants having herbicide resistance, insect resistance, altered fatty acid composition in *Brassica* oil, resistance against stresses, male sterility and fertility restoration.
- 11) Molecular farming, production of edible vaccines, plants with enhanced nitrogen fixing ability; release of GM plants to the environment and public perception.
- 12) Intellectual Property Rights.

Biostatistics

- 13) Biostatistics - definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.
- 14) Collection of data, primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data - sampling methods, Sampling errors – Type I error, Type II error.
- 15) ANOVA – Introduction, Test of ANOVA, F-test, Assumptions of ANOVA Statistical inference - hypothesis - simple hypothesis - student 't' test - chi square test.

- 16) Non-Parametric or distribution free statistical tests- Introduction, Advantages and Non-advantages of non-parametric test, Situations for the use of non-parametric tests.
- 17) Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression. Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); sampling distribution; difference between parametric and non-parametric statistics; confidence interval; errors; levels of significance;

**Paper-XV : Practical Paper
BOT E15**

Elective Theory 'C'

Molecular Biology and Plant Biotechnology

Credits: 05

Full Marks: 70

Time: 06 Hrs.

1. Preparation of LB medium and raising *E.Coli*.
2. Isolation of genomic DNA from the given leaf sample.
3. DNA estimation by UV Spectrophotometry.
4. To separation DNA (marker) using AGE.
5. Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants .
6. Restriction digestion and gel electrophoresis of plasmid DNA
7. Sequence alignment.
8. Problems related to Mendelian ratios and their modifications; statistical analysis and genetic explanation.

**Paper-XVI : Project Work
BOT E16**

Credits: 05

Full Marks: 100

Time: 06 Hrs.

Each student will have to perform Project Work (Experimental or Review) under the Supervision of a teacher and will submit a Project Report in the Department at the end of the session i.e. before Theory Papers Examination begins.