SYLLABUS

BOTANY

(UNDER COSIST PROGRAM)

M.Sc. (PREVIOUS) EXAMINATION, 2015

M.Sc. (FINAL) EXAMINATION, 2016

JAI NARAIN VYAS UNIVERSITY

JODHPUR

POST-GRADUATE STUDIES IN BOTANY

(COSIST Program) 2015-16

General Information for Students

Jai Narain Vyas University (erstwhile University of Jodhpur), Jodhpur (established in July, 1962), had been a residential University operating within the Municipal limits of Jodhpur city. As per notification of Govt. of Rajasthan dated 26 September, 2012 all colleges situated in Barmer, Jaisalmer, Jalore and Pali districts shall be affiliated to Jai Narain Vyas University, Jodhpur. The Department of Botany is situated in the New Campus of the University, near the Bhagat-ki-Kothi Railway Station along Pali Road.

The Department of Botany imparts post-graduate education in the fields of Plant Sciences and allied subjects. This department has made impressive progress in research and teaching activities during the last 50 years. Students and Researchers work for their Ph.D. and D.Sc. degree in the Department of Botany. About eight laboratories are actively engaged in different areas of plant research. The research and development activities attract national and international attention. Research and Development projects are funded by national and international agencies. These include, The European Economic Community, FAO, UNDP/UNIDO, PL480, CSIR, UGC, DST, DBT, DRDO, DOEn, ICAR, ICFRE, CSB, Ministry of Health and State DST. Since 1980 this department has been receiving grants under Special Assistance Program (SAP) of the University Grants Commission of India. UGC Sponsored SAP-DSA Phase III Program has been successfully completed and the next phase (CAS) is under review. Since 1980 grants worth Rs. 500 lakhs have been received for development of infrastructure and for implementation of R&D Projects.

In 1983, on the recommendation of the Science Advisory Committee to the Cabinet (SACC), the University Grants Commission of India launched the COSIST (Committee on Strengthening of Infrastructure in Science and Technology). The basic objective of COSIST is to assist selected Science and Technology departments in the Indian Universities; which has already exhibited and achieved high quality performance to attain excellence in the post-graduate education and research. The department of Botany has been selected for implementation of COSIST program by the UGC from April 1999 for raising the standard of post-graduate education and research to international level. The M.Sc. (COSIST) Botany course under this new scheme was started from July 1999. This department is selected by the Department of Science and Technology, Government of India for support under FIST (Funds for Improvement of S & T Infrastructure). FIST program-I was completed successfully and FIST program-II is in operation.

ACADEMIC AND RESEARCH PROGRAMMES IN PLANT SCIENCES

Under the new COSIST system, the Department of Botany offers a two years integrated program leading to Masters (M.Sc.) degree in Botany.

Students are admitted on an all India basis. The basic specializations offered are in the areas of Stress Physiology and Biochemistry, Physiology of Plant Growth, Ecology and Environmental Biology, Plant Microbe-Interactions, Mycology and Plant Pathology, Biological Nitrogen Fixation, Molecular characterization of Bacteria/rhizobia, Bacterial genomics, Microbiology, Genetics and Plant Breeding, Plant Resources, Systematics and Biodiversity, Plant Molecular Biology, Biotechnology, Plant Prospecting and Plant genomics.

The Department continues with the same evaluation scheme of that of COSIST. The Department has facilities for advance research in major areas of plant biology leading to Ph.D. and D.Sc. degree.

FACILITIES

The Department possesses modern equipments required for teaching and research. Major equipments available in the department of Botany are:

Chlorophyll Fluorescence Meter

Computer Networking System

Electrophoresis Systems: 1-D and 2-D

Humidifiers and Fog Systems

Laminar Air Flow Benches

Li-6400 PS

Micropropagation/Green House Facilities

Microscopes with photo-micrographic attachments

Nat Steel Autoclave(s)

Osmometer

Plant Canopy Analyzer

Portable Photosynthetic Systems (USA)

Incubator(s) and Incubator Shaker

Spectrofluorimeter-JASCO

UV-VIS-Spectrophotometers

Steady State Porometer

Millipore Water Purification System

Electroporation cum Protoplast Fusion System

Master Thermal Cycler (PCR Machines)

Real Time-PCR

Submerged Electrophoresis System

Super Speed Refrigerated Centrifuge

HPLC system

Agarose Electrophoresis System(s)

Ice making machine

Industrial Oven

Cold Room

Gel Documentation Systems

Deep Freezers

Ultra Freezer

Microtome

Fluorescence Microscope

Slide/Overhead Projectors/Multimedia System/ Smart Board

In addition, there are other facilities to work with certain instruments available with U.S.I.C. The Departmental library caters to the needs of post-graduate students, research scholars and the faculty members.

POST -GRADUTE COURSE: A DESCRIPTION

The academic program at M.Sc. level is through a semi-annual examination scheme. The course work includes lectures, seminars and laboratory works. It shall be compulsory for all students to attend at least one long distance excursion either to a hill station or to seashore or to desert area for field study and for collection of plant materials for class work in addition to 3 to 4 local excursions. A student appearing as ex-student who has not taken part in long and short excursions as regular student will not be entitled for

the marks allotted for excursion. For every 15 students or part thereof, one teacher shall accompany the party.

The full course is of Two Years duration. A list of courses to be offered is given below:

B-401: Cell and Molecular Biology of Plants

B-402: Cytology, Genetics, Cytogenetics and Plant Breeding

B-403: Biology and Diversity of Lower Plants: Cryptogams

B-404: Taxonomy and Diversity of Seed Plants

B-405: Plant Physiology and Metabolism

B-501: Plant Development and Reproduction

B-502: Plant Ecology

B-503: Plant Resource Utilization and Conservation

B-504: Biotechnology and Genetic Engineering of Plants and Microbes

B-505: Stress Biology

B-506: Weed Biology

B-507: Population Biology and Desert Ecology

B-510: Molecular Biology and Plant Biotechnology

B-511: Plant Microbe-Interactions (PMIs)

ADMISSION

The minimum qualification for admission to M.Sc. Course is B.Sc. (10+2+3) degree with Botany as a major subject. The details of eligibility conditions and admission procedure are given in the admission form. The admission will be done on the basis of merit calculated by the aggregate marks obtained at the B.Sc. level including the marks award under the category (a) and (b) mentioned in the admission from [i.e. (a) benefit to the candidates who are resident of Rajasthan, and (b) benefit for candidates of J. N. Vyas University, Jodhpur]. Reservation of Scheduled Caste/Scheduled Tribes/Disabled/OBC and Teacher candidates will be as per university rules. The candidates are required to attend minimum of a 75% of classes in both theory and practical.

SPECIALISATION AND THE PROCESS OF EVALUATION

Each paper will be of 100 marks in theory and 50 marks in practical in M.Sc. (Prev.) and M.Sc. (Final). 50% of the marks of each theory paper course and 25% marks of practicals will be awarded through internal assessment and rest (50% in Theory, 75% in Practical) by the external Assessment (University Examination). All theory papers shall be evaluated externally, i.e. by teachers of other University. The internal assessment of each theory paper shall be carried through term examinations, quizzes and seminars. The marked answer book/sheets of the internal assessment will be placed before the students. There shall be university examination at the end of each year. The minimum pass marks in each paper will be 45% and the candidate must get 48% aggregate in practicals.

SCHEME OF INTERNAL EVALUATION

Each paper shall be evaluated thorough 3 quizzes, 2 term tests and 1 seminar. The following shall be the marking scheme:

Three Quizzes	120 Marks
First Term Test	35 Marks
Second Term Test	70 Marks
Seminar	25 Marks
Total	250 Marks

These marks are then reduced to 50% and reported to the university.

RULES FOR THE FINALISATION OF RESULTS

The following rules shall be observed in finalization of the results of M.Sc. (Prev.) and M.Sc. (Final) Examinations (COSIST Program):

1. To pass a candidate must secure 45% of marks in each theory paper with an aggregate of 48% in all the theory papers.
2. To pass a candidate must secure a minimum of 48% of marks of each practical examination.
3. A candidate is allowed the benefit of re-evaluation after each annual examination as per university rules. There shall be no re-evaluation in internal assessment and practical examination.
4. Rules for the award of grace marks for M.Sc. (Prev.) and M.Sc. (Final) Botany (COSIST) Examination will be as per university rules.

CURRICULUM FOR M.Sc. (PREVIOUS) PROGRAM

B-401: Cell and Molecular Biology of Plants

B-402: Cytology, Genetics, Cytogenetics and Plant Breeding

B-403: Biology and Diversity of Lower Plants: Cryptogams

B-404: Taxonomy and Diversity of Seed Plants

B-405: Plant Physiology and Metabolism

UNIVERSITY EXAMINATION

Each course paper shall be of three hours duration.

PRACTICALS

The practical examination in M.Sc. (Prev.) shall consist of Three Parts- Board I, Board II and Board III. Each Board will consist of external and internal examiners.

BOARD I: Maximum Marks: 100 (including 25% internal assessment marks). It includes course work of B-401 and B-402. Internal assessment marks are based on long, short educational excursions, herbarium collection, class-work, the records and Hands-on-experiments. Duration: Six hours in a single day.

BOARD II: Maximum Marks: 100 (including 25% internal assessment marks). It includes course work of B-403 and B-404. Internal assessment marks are based on hands-on-experiments, records, field work and material collection. Duration: Six hours in a single day.

BOARD III: Maximum Marks: 50 (including 25% internal assessment marks). It includes course work B-405. Internal assessment marks are based on hand-on-experiments, records, field work and material collection. Duration: Three hours of a single day.

CURRICULUM FOR M.Sc. (FINAL) PROGRAM

Compulsory Courses

B-501: Plant Development and Reproduction

B-502: Plant Ecology

B-503: Plant Resource Utilization and Conservation

B-504: Biotechnology and Genetic Engineering of Plants and Microbes

Elective Course: The student shall offer any ONE of the following elective paper of specialization:

B-505: Stress Biology

B-506: Weed Biology

B-507: Population Biology and Desert Ecology

B-510: Molecular Biology and Plant Biotechnology

B-511: Plant Microbe-Interactions (PMIs)

UNIVERSITY EXAMINATION

Theory: Each course paper shall be of 3 hours duration.

The Practical examination in M.Sc (Final) shall consist of Three Parts-Board I, Board II and Board III. Separate Board of external and internal examiners shall examine each Board.

BOARD I: Maximum Marks: 100 (including 25% internal assessment marks). It includes course work of B-501 and B-502. Internal assessment marks are based on hands-on-experiments, records, fieldwork and material collection. Duration: Six hours in a single day.

BOARD II: Maximum Marks: 100 (including 25% internal assessment marks). It includes course work of B-503 and B-504. Internal assessment marks are based on long & short educational excursions, hands-on experiments, records, fieldwork and material collection. Duration: Six hours in a single day.

BOARD III: Maximum Marks: 50 (including 25% internal assessment marks). It includes elective course comprising Paper V. Internal assessment marks are based on hands-on-experiments, records, field work/project work and material collection. Duration: Three hours in a single day.

Note: Number of elective to be taught in a particular year shall be decided by the Department. Elective offered will be announced at the beginning of the academic session. Elective papers will be allotted on merit-cum-choice basis with equal number of students in each paper.

TEACHING AND EXAMINATION SCHEME

M. Sc. (Previous)

	Periods/ Week	Internal Assessment	External Assessment		Total
THEORY (FIVE PAPERS)					
Course B 401	4	50	50		100
Course B 402	4	50	50		100
Course B 403	4	50	50		100
Course B 404	4	50	50		100
Course B 405	4	50	50		100
				Total	500
PRACTICALS					
Course B 401	6	12	38		50
Course B 402	6	12	38		50
Course B 403	6	12	38		50
Course B 404	6	12	38		50
Course B 405	6	12	38		50
				Total	250
				Grand Total	750

Students are required to pass in theory and practicals separately.

Minimum pass marks of each theory paper = 45%

Minimum pass marks of practicals = 48%

A candidate must get 48% marks in aggregate of theory for passing M.Sc. (Previous) Examination, i.e. 240 marks out of 500.

TEACHING AND EXAMINATION SCHEME

M. Sc. (Final)

	Periods/ Week	Internal Assessment	External Assessment		Total
THEORY (FIVE PAPERS)					
Course B 501	4	50	50		100
Course B 502	4	50	50		100
Course B 503	4	50	50		100
Course B 504	4	50	50		100
Elective (One Course)					
Course I	4	50	50		100
				Total	500
PRACTICALS					
Course B 501	6	12	38		50
Course B 502	6	12	38		50
Course B 503	6	12	38		50
Course B 504	6	12	38		50
Elective (One Course)					
Course I	6	12	38		50
				Total	250
			Grand Total	M. Sc. (Previous)	750
				M. Sc. (Final)	750
					1500

Students are required to pass in Theory and Practicals separately.

Minimum pass marks of each Theory paper	45%
Minimum pass marks of Practicals	48%

A candidate must get 48% marks in aggregate of theory for passing M.Sc. (Final) Examination, i.e. 240 marks out of 500

48% and above but less than 60% (i.e. 720 to 899/1500)	II Division
60% and above (i.e. 900 and above out of 1500)	I Division

M.Sc. (Previous) Botany Examination, 2015

Paper – I

B–401: Cell and Molecular Biology of Plants

Unit 1: Concept of cell and cell theory. The dynamic cell: Origin of cell and multicellularity; Structural organization of plant cell. Specialized plant cell types. Chemical foundation: Covalent and non-covalent bonds. Structure of proteins, lipids and carbohydrates. Biochemical energetics: Various forms of energy and their interrelationships in living systems. Cell Wall: biochemistry and molecular biology of cell wall biogenesis. Nature of cell wall. Growth and its function. Macromolecules, architecture-type I and type II.

Unit 2: Plant vacuole: Tonoplast membrane transporters and storage organelle. Ribosomes: structure, site of protein synthesis; mechanism of translation, initiation, elongation and termination; structure and role of tRNA. Structure and function of Endoplasmic Reticulum (ER), ER-associated SNARE proteins.

Plasmodesmata: Composition and structure; signaling and movement of molecules and macromolecules; other functions; comparison with gap junctions.

Unit 3: Endosymbiosis theory and ancestry of plastids. Division and development of plastids. Nature, organization and functioning of plastome.

Mitochondria – Structure, division, biogenesis and development to mitochondria. Genome organization. Hydrogenosome.

Regulation of expression of gene(s) in plastid and mitochondria, RNA editing. Interactions among organelles and nucleus. Cytoplasmic inheritance.

Unit 4: Nucleus: Ultra structure, nuclear pores, mechanism of export and import of macromolecules, molecular structure of DNA, DNA replication and DNA polymerases. Transcription factors, promoters and splicing. DNA damage and repair. Nucleolus, rRNA biosynthesis. Cell cycle, Control mechanisms, role of cyclins and cyclin dependent kinases, cytokinesis and cell plate formation; retinoblastoma and E2F proteins. Apoptosis, mechanism of programmed cell death in plants and its importance.

Unit 5: Plasma membrane: structure, models and functions; sites for ATPases, ion carriers, channels, pumps and receptors. Cell shape and motility: The cytoskeleton; organization and role of microtubules and microfilaments; motor movements; implications in flagellar and other movements. Protein sorting: Targeting of proteins to organelles. Techniques in cell biology: Immuno techniques; chromosome microdissection and microcloning. Flow Cytometry. Principles of microscopy and optics (light, fluorescence, electron, confocal and atomic force microscopy).

LABORATORY EXERCISES

1. Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
2. Isolation of chloroplasts and SDS-PAGE profile of proteins to demarcate the two subunits of Rubisco.
3. Isolation of plant DNA and its quantitation by a spectrophotometric method.
4. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
5. Isolation of RNA and quantitation by a spectrophotometric method.
6. Separation of plant RNA by agarose gel electrophoresis and visualization by EtBr staining.

7. Fluorescence staining with FDA for cell viability and cell wall staining with calcofluor white.
8. Isolation of DNA and preparation of *cot* curve.
9. Southern blot analysis using a gene specific probe.
10. Northern blot analysis using a gene specific probe.
11. Immunological techniques: Ouchterlony method, ELISA and western blotting.
12. Demonstration of SEM and TEM.
13. Tagging of root nodule bacteria with GFP gene and screening of transconjugants.
14. Insertion of GUS gene in root nodule bacteria and screening of transconjugants.

SUGGESTED READINGS

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. 1999. *Molecular Biology of the Cell*. Garland Publishing, Inc., New York.

Buchanan, B. B., Gruissem, W. and Jones, R. L. 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, Maryland, USA

De, D. N. 2000. *Plant Cell Vacuoles: An Introduction*. CSIRO Publication, Collingwood, Australia.

Glick, B. R. and Thompson, J. E. 1993. *Methods in Plant Molecular Biology and Biotechnology*. CRC Press, Boca Raton, Florida.

Glover, D. M. and Hames, B. D. (eds) 1995. *DNA Cloning 1: A Practical Approach-, Core Techniques*, 2nd edition, PAS, IRL Press at Oxford University Press, Oxford.

SUGGESTED READINGS (FOR LABORATORY EXERCISES)

Gunning, B. E. S. and Steer, M. W. 1996. *Plant Cell Biology: Structure and Function*. Jones and Bartlett Publishers, Boston, Massachusets.

Hackett, P. B., Fuchs, J. A. and Messing, J. W. 1988. *An Introduction to Recombinant DNA Techniques: Basic Experiments in Gene Manipulation*. The Benjamin/Cummings Publishing Co., Inc Menlo Park, California.

Hall, J. L. and Moore, A. L. 1983. *Isolation of Membranes and Organelles from Plant Cells*. Academic Press, London, UK.

Harris, N. and Oparka, K. J., 1994. *Plant Cell Biology: A Practical Approach*, IRL Press at Oxford University Press, Oxford, U.K.

Kleinsmith, L. J. and Kish, V. M. 1995. *Principles of Cell and Molecular Biology* (Edition), Harper Collins College Publishers, New York, USA.

Krishnamurthy, K. V. 2000. *Methods in Cell Wall Cytochemistry*. CRC Press, Boca Raton, Florida.

Lewin, B. 2000. *Genes VII,* Oxford University Press, New York.

Lodish, H., Berk, A., Zipursky, S. L., Malsudaira, P., Baltimore, D. and Darnell, J. 2000. *Molecular Cell Biology* (V Edition). W.H. Freeman and Co., New York, USA.

Rost, T. et al., 1998. *Plant Biology*. Wadsworth Publishing Co., California, USA.

Shaw, C. H. (Ed.), 1988. *Plant Molecular Biology: A Practical Approach.* IRL Press, Oxford.

Wolfe, S. L. 1993. *Molecular and Cellular Biology*. Wadsworth Publishing Co., California, USA.

Review Journals:

Annual Review of Plant Physiology and Molecular Biology.

Current Advances in Plant Sciences.

Trends in Plant Sciences.

Nature Reviews: Molecular and Cell Biology.

Paper – II

B–402: CYTOLOGY, GENETICS, CYTOGENETICS AND PLANT BREEDING

Unit 1: Genome organization: Chromosome structure and packaging of DNA, molecular organization of centromere and telomere; euchromatin and heterochromatin; Chromosomal banding patterns, karyotype analysis and evolution; specialized types of chromosomes; polytene, lampbrush, B-and sex chromosome. Molecular basis of chromosome pairing.

Structural and numerical alterations in chromosomes: origin, meiosis and breeding behaviour of duplications, deficiency, inversion and translocation heterozygotes. Origin and occurrence of haploids, meiosis in haploids. Polyploids (aneuploids, euploids, autopolyploids and allopolyploids). Trisomics and monosomics.

Unit 2: Genetics of prokaryotes and eukaryotes: Genetic recombination of phage genome; genetic transformation, conjugation and transduction in bacteria. Fine structure of prokaryotic and eukaryotic genes. Regulation of gene expression in prokaryote: initiation of transcription, RNA polymerases, *lac* operon, tryptophan operon, attenuation and RNA regulators.

Regulation of gene expression in eukaryotes: transcription; RNA polymerases, regulator binding sites, transcription activator factors, post transcription, translation and post translation modifications/regulations. Introns and their significance, RNA splicing.

Unit 3: Genetic recombination and genetic mapping: Independent assortment, crossing over, linkage groups and chromosome mapping. Correlation of genetic and physical maps; somatic cell genetics- an alternative approach to gene mapping. Molecular mechanism of recombination: ss DNA and ds DNA breakage models, role of RecA and RecBCD enzymes; site-specific recombination. Mutations: spontaneous and induced mutations, molecular mechanisms of physical and chemical mutagens; repair mechanisms, reverse genetics. Transposable elements in prokaryotes and eukaryotes; mutation induced by transposons, site directed mutagenesis.

Unit 4: Genetics, evolution and breeding of major crop plants– Wheat, Rice, Cotton, Sugarcane, Potato, Brassica and Groundnut; Transfer of whole genome (examples frorm wheat, Arachis and Brassica); transfer of individual chromosomes and chromosome segments methods for detecting alien chromatin, characterization and utility of alien addition and substitution lines, Genetic basis of inbreeding and heterosis, exploitation of hybrid vigor, Male sterility and its application on crop improvement.

Unit 5: Molecular cytogenetics: concept and technique of restriction mapping and *in situ* hybridization. Construction of genetic or molecular maps. Genetic analysis: complementation, dominance, codominance, variable expressivity and incomplete penetrance. Chromatin remodeling, epigenetic and

genome imprinting. Population genetics: allele and genotype frequencies, enzyme and DNA polymorphism, DNA typing and population substructure.

LABORATORY EXERCISES

1. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
2. Silver banding for staining nucleolar-organizing region, where 18S and 28S rDNA are transcribed.
3. Orcein and Feulgen staining of chromosomes.
4. Characteristics and behaviour of B chromosomes using maize or any other appropriate material.
5. Working out the effect of mono and tri-somy on plant phenotype, fertility and meiotic behaviour.
6. Induction of polyploidy using colchicine; different methods of the application of colchicine.
7. Effect of induced and spontaneous polyploidy on plant phenotype, meiosis, pollen and seed fertility and fruit set.
8. Effect of translocation heterozygosity on plant phenotype, chromosome pairing and chromosome disjunction and pollen and seed fertility.
9. Meiosis of complex translocation heterozygotes.
10. Basic exercises of plant breeding.
11. Action of transposons.
12. Estimation of nuclear DNA content through microdensitometry and flow cytometry.
13. Fractionation and estimation of repetitive and unique DNA sequences in nuclear DNA.
14. Distribution pattern of a biological character in a population.

SUGGESTED READINGS

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. 1989. *Molecular Biology of the Cell* (2nd edition). Garland Publishing Inc., New York.

Atherly, A. G., Girton, J. R. and McDonald, J. F. 1999. *The Science of Genetics*. Saunders College Publishing, Fort Worth, USA.

Burnham, C. R. 1962. *Discussions in Cytogenetics*. Burgess Publishing Co., Minnesota.

Busch, H. and Rothblum, L. 1982. Volume X. *The Cell Nucleus rDNA Part A*. Academic Press.

Hartl, D. L. and Jones, E. W. 1988. *Genetics: Principles and Analysis* (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.

Hoshmand A. Reza, 1988. *Statistical methods for environmental & Agricultural Sciences,* CRC Press, Florida.

Karp, G. 1999. *Cells and Molecular Biology: Concepts and Experiments*. John Wiley & Sons, Inc., U.S.A.

Khush, G. S. 1973. *Cytogenetics of Aneuploids*. Academic Press, New York, London.

Lewin, B. 2000. *Gene VIII*. Oxford University Press, New York, USA.

Lewis, R. 1997. *Human Genetics: Concepts and Applications* (2nd edition). WCB McGraw Hill, USA.

Malacinski, G. M. and Freifelder, D. 1998. *Essentials of Molecular Biology* (3rd edition). Jones and Bartlet Publishers, Inc., London.

Panse, V. G. and Sukhatme, P. V. 1989. *Statistical methods for agricultural workers*, ICAR, New Delhi.

Russel, P. J. 1998. *Genetics* (5th edition). The Benjamin/Cummings Publishing Company Inc., USA.

Snustad, D. P. and Simmnns, M. J. 2000. *Principles of Genetics* (2nd edition). John Wiley & Sons Inc., USA.

SUGGESTED READINGS (FOR LABORATORY EXERCISES)

Fukui, K. and Nakayama, S, 1996. *Plant Chromosomes: Laboratory Methods*. CRC Press, Boca Raton, Florida.

Sharma, A. K. and Sharma, A. 1999. *Plant Chromosomes: Analysis, Manipulation and Engineering*. Harwood Academic Publishers, Australia.

PAPER – III

B–403: BIOLOGY AND DIVERSITY OF LOWER PLANTS

Unit 1: Microbiology: General account of Archaebacteria, Eubacteria, Actinomycetes, Cyanobacteria, Mycoplasma, Phytoplasma and yeast. Ultrastructure of Bacteria. Biofilms and quorum sensing.
Viruses: morphology, architecture, chemistry, isolation and purification, transmission and genetics of viruses. General account of AIDS and Prions.

Unit 2: Phycology: Algae in diversified habitats; thallus organization; cell ultrastructure; reproduction; criteria for classification of algae. Classification and salient features of Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta. Algal blooms, algal biofertilizers; algae as food, feed and uses in industry.

Unit 3: Mycology: General characters and classification of fungi. Phylogeny of fungi. General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina. Fungi in industry; Mycorrhizae; General concepts of plant pathology.

Unit 4: Bryophyta: Morphology, structure, reproduction and life history; distributions; classifications; general account of Marchantiales, Junger-maniales, Anthocerotales, Sphagnales, Funariales and Polytrichales; economic and ecological importance.

Unit 5: Pteridophyta: Classification; evolution of stele; heterospory and origin of seed habit; general account of fossil pteridophyta; morphology, anatomy and reproduction: introduction to Psilopsida, Lycopsida, Sphenopsida and Pteropsida.

LABORATORY EXERCISES

Study of Morphology of Bacteria, Viruses, Phytoplasma and Cyanobacteria by charts or slides.

Culturing of Bacteria

Gram Staining of Bacteria

Morphological study of representative members of algae, fungi, bacteria, bryophytes and pteridophytes: *Lyngbya, Scytonema, Microcystis, Pediastrum, Hydrodictyon, Ulva, Pithophora, Sitgeoclonium, Drapranaldiopsis, Closterium, Cosmarium, Chara, Ectocarpus, Polysiphonia, Sargassum, Peronospora, Albugo, Mucor, Rhizopus Pilobolus, Yeast, Chaetomium, Alternaria Curvularia,. Morchella, Melampspora, Polyporus, Drechslera, Phoma, Penicillium, Aspergillus, Colletotrichum, Marchantia, Dumortia, Targionia, Reboulia, Asterella, Cythodium, Pellia, Porella, Anthoceros, Notothylus, Sphagnum, Funaria, Polytrichum, Psilotum, Lycopodium, Selaginella, Equisetum, Gleichenia, Pteris, Ophioglossum, Isoetes, Osmunda*.

Symptomology of some diseased specimens: White rust, downy mildew, powdery mildew, rusts, smuts, ergot, groundnut leaf spot, red rot of sugarcane, wilts, paddy blast, citrus canker, bacterial blight of paddy, angular leaf spot of cotton, tobacco mosaic, little leaf of brinjal, seasame phyllody, mango malformation.

Study of morphology, anatomy and reproductive structures of bryophytes and pteridophytes.

Identification of fungal cultures: *Rhizopus, Mucor, Aspergillus*, *Penicillium*, *Chaetomium, Drechslera, Curvularia, Fusarium, Phoma, Colletotrichum, Alternaria*.

Sterilization methods, preparation of media and stains.

SUGGESTED READINGS

Alexopoulus, C. J., Mims, C. W. and Blackwel, M. 1996. *Introductory Mycology*. John Wiley & Sons Inc.

Clifton, A. 1958. *Introduction to the Bacteria*. McGraw-Hill Book Co., New York.

Kumar, H. D. 1988. *Introductory Phycology*. Affiliated East-West Press Ltd., New Delhi.

Mandahar, C. L. 1978. *Introduction to Plant Viruses*. Chand & Co. Ltd., Delhi.

Mehrotra, R. S. and Aneja, R. S. 1998. *An Introduction to Mycology*. New Age Intermediate Press.

Morris, I. 1986. *An Introduction to the Algae*. Cambridge University Press, U.K.

Parihar, N. S. 1991. *Bryophyta*. Central Book Depot, Allahabad.

Parihar, N. S. 1996. *Biology & Morphology of Pteridophytes*. Central Book Depot, Allahabad.

Puri, P. 1980. *Bryophytes*. Atma Ram & Sons, Delhi.

Rangaswamy, G. and Mahadevan, A. 1999. *Diseases of Crop Plants in India* (4" edition). Prentice Hall of India Pvt. Ltd., New Delhi.

Round, F. E. 1986. *The Biology of Algae*. Cambridge University Press, Cambridge.

Sporne, K. K. 1991. *The Morphology of Pteridophytes*. B,I. Publishing Pvt. Ltd., Bombay.

Stewart, W. N. and Rathwell, G. W. 1993. *Paleobotany and the Evolution of Plants*. Cambridge University Press.

Webster, J. 1985. *Introduction to Fungi*. Cambridge University Press.

Paper – IV

B-404: TAXONOMY AND DIVERSITY OF SEED PLANTS

UNIT 1: GYMNOSPERMS: General characters and classification of Gymnosperms. Structure and reproduction in Cycadales, Ginkgoales, Coniferales, Ephedrales, Welwitschiales and Gnetales. Diversity and evolution of male and female gametophytes of Gymnosperms. Diversity and distribution of Gymnosperms of India.
Geological Time Scale. Evolution of Gymnosperms- a general account. General characters, classification and evolutionary significance of Pteridospermales (Lyginopteridaceae, Medullosaceae, Caytoniaceae and Glossopteridaceae), Cycadeoidales and Cordaitales.

UNIT 2: ANGIOSPERMS: Plant Taxonomy-principles and significance. Nomenclature: International Code of Botanical Nomenclature (2012)-Taxonomic hierarchy-concept of species, genus, family and other categories; typification, rule of priority, effective and valid publication. Angiosperm classifications: Phenetic versus phylogenetic systems; cladistics in taxonomy. Classification, relative merits and demerits of major systems of classifications-Bentham and Hooker, Cronquist, Takhtajan, Angiosperm Phylogeny Group (III).

UNIT 3: TAXONOMIC TOOLS
Plant explorations. Herbarium methodology-collection and preservation of plant specimens. World and Indian herbaria. Plant identification-taxonomic keys; floras and taxonomic journals.
Taxonomic evidence: Morphology, Anatomy, Palynology, Embryology, Cytology, Phytochemistry, Nucleic acid hybridization as a tool in taxonomy; DNA Barcoding. Computer databases and Geographical Information systems.

UNIT 4: BIOSYSTEMATICS AND PHYTOGEOGRAPHY
Biosystematic categories-Ecotype: nature, origin and their significance, different types of ecotypes, ecospecies, coenospecies, comparium; phenotype, genotype, biotype; deme concept. Infra specific and Inter specific variations. Genecotypes and phenecotypes. Plasticity of phenotypes; factors affecting phenotype variations and their significance, role of biosystematics in evolution.
Principles of phytogeography: Static and dynamic concepts. Continental drift theory and Endemism. Biodiversity hotspots. Invasions and introductions; Local plant diversity and its socio-economic importance.

UNIT 5: STUDY OF SELECTED ANGIOSPERM ORDERS
Salient features, floral diversity, diversity of families and phylogeny of the following orders: Ranales, Centrospermae, Amentiferae, Tubiflorae, Helobieae and Glumiflorae.

PRACTICALS

1. Comparative study of the anatomy of vegetative and reproductive parts of *Cycas, Ginkgo, Cedrus, Abies, Picea, Cupressus, Araucaria, Cryptomeria, Taxodium, Podocarpus, Agathis, Taxus, Ephedra* and *Gnetum*
2. Study of important fossil gymnosperms from prepared slides and specimens.
3. Study of about 40 wild taxa representing different families and identification to species level.

4. Study of flora of the University/ college campus.
5. As a part of botanical tour, student should observe and record the flora and vegetation types of the study area and submit a report at the time of practical examination.
6. Part of practical - student should submit 10 herbaria specimens or image softcopies of 10 plants of common wild plant taxa.
7. Construction of taxonomic keys.
8. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
9. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.
10. Nomenclatural exercise.

SUGGESTED READINGS

Angiosperm Phylogeny Group website. 2012. consult www.apgweb.

Bhatnagar, S. P. and Moitra, A. 1996. *Gymnosperms*. New Age International Pvt. Ltd., New Delhi.

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Davis, P. H. and Heywood, V. A. 1973. *Principles of Angiosperms Taxonomy*. Robert E. Kreiger Pub. Co-, New York.

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Heslop-Harrison, J. 1967. *Plant Taxonomy*. English Language Book Soc. & Edward Arnold Pub. Ltd., UK.

Heywood, V. H., Brummitt, R. K., Culham, A. and Seberg, O. 2007. *Flowering Plant Families of the World*. Firefly books Ltd. New York.

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Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F. and Donoghue, M. J. 2007. *Plant Systematics: A Phylogenetic Approach*, 3rd ed. Sinauer.

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Radford, A. E. 1986. *Fundamentals of Plant Systematics*. Harper & Row Publications, USA.

Radford. A. E. *et.al.,* 1974. *Vascular Plant Systematics*. Harper & Row, New York.

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Sivarajan, V. V. 1991. *Introduction to Principles of Plant Taxonomy.* Oxford & IBH.

Solbrig, O. T. 1970. *Principles and Methods of Plant Biosystematics*. The MacMillan Co. Collier-Mac Millan Ltd., London.

Solbrig, O. T. and Solbrig, D. J. 1979. *Population Biology and Evolution*. Addison-Wesley Publicating Co. Inc., USA.

Stace, C. A. 1989. *Plant Taxonomy and Biosystematics*. Edward Arnold Ltd., London.

Stebbin, G. L. 1974. *Flowering Plant- Evolution Above Species Level*. Edward Arnold Ltd., London,

Takhtajan, A. L. 1997. *Diversity and Classification of Flowering Plants*. Columbia University Press, New York.

Woodland, D. W. 1991. *Contemporary Plant Systematics*. Prentice Hall, New Jersey.

Paper – V

B-405: PLANT PHYSIOLOGY AND METABOLISM

UNIT 1: Fundamentals of enzymology: General aspects, allosteric mechanism, regulatory and active sites, isozymes. Membrane transport and translocation of water and solutes: Plant-water relations, mechanism of water transport through xylem, root-microbe interactions in facilitating nutrient uptake, comparison of xylem and phloem transport, phloem loading and unloading, passive and active solute transport, membrane transport proteins.

UNIT 2: Photochemistry and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photooxidation of water, mechanisms of electron and proton transport, carbon assimilation- the Calvin cycle, photo respiration and its significance, the C_4 cycle, the CAM pathway. Regulation of C_3 cycle. Biosynthesis of starch and sucrose, physiological and ecological considerations.

Respiration and lipid metabolism: Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, glyoxylate cycle, alternative oxidase system, fatty acids and their metabolism.

UNIT 3: Signal transduction: Overview, receptors, signaling molecules, G-proteins, phospholipids signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity in protein kinases and phosphatases, specific signaling mechanisms, e.g. two-component sensor-regulator system in bacteria and

plants. Sensory photobiology: History of discovery of phytochromes, cryptochromes and phototropins, their photochemical and biochemical properties. Photophysiology of light-induced responses, cellular localization. Brief account of molecular mechanism of action of photomorphogenic receptors.

UNIT 4: Plant growth regulators: Physiological effects and general mechanism of action of plant hormones. Specific mode of actions of auxins (cell enlargement), gibberellins (*de novo* alpha amylase secretion), cytokinins (delaying senescence, cell division), ethylene (fruit ripening, vase life) and abscisic acid (environmental stress). Brief account on brassinosteroids, polyamines, Jasmonic acid, salicylic acid and nitric oxide (NO). Hormone mutants. The flowering process: Photoperiodism and its significance, endogenous clock and its regulation. Vernalization.

UNIT 5: Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and Nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation, sulfate uptake, transport and assimilation. Stress physiology- Plant responses to biotic and abiotic stress, general mechanisms of abiotic stress tolerance, HR and SAR, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress and antioxidants system in plants.

LABORATORY EXERCISES

1. Effect of time and enzyme concentration on the rate of reaction of enzyme (e.g. acid phosphatase, nitrate reductase).
2. Demonstration of the substrate inducibility of the enzyme nitrate reductase.
3. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum of chlorophylls and carotenoids.
4. To determine the chlorophyll a/chlorophyll b ratio in C3 and C4 plants.
5. Extraction of seed proteins depending upon the solubility.
6. Desalting of proteins by gel filtration chromatography employing Sephadex G25.
7. Preparation of the standard curve of protein (BSA) and estimation of the protein content in extracts of plant material by Lowry's or Bradford's method.
8. Fractionation of proteins using gel filtration chromatography by Sephadex G100 or Sephadex G200.
9. SDS-PAGE for soluble proteins extracted from the given plant materials and comparison of their profile by staining with Coomassie Brilliant Blue or silver nitrate.
10. Separation of isozymes of esterases, peroxidases by native polyacrylamide gel electrophoresis.
11. Principles of colorimetry, spectrophotometry and fluorimetry.
12. Effect of substrate concentration on activity of any enzyme and determination of its Km value.
13. Isolation of intact chloroplasts and estimation of chloroplast proteins by spot protein assay.
14. To demonstrate photophosphorylation in intact chloroplasts, resolve the phosphoproteins by SDS-PAGE and perform autoradiography.
15. Radioisotope methodology, autoradiography, instrumentation (GM counter and Scintillation counter) and principles involved.

SUGGESTED READINGS

Buchanan, B. B., Gruissem, W. and Jones, R. L. 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists. Maryland, USA.

Dennis, D. T., Turpin, D. H., Lefebvre, D. D. and Layzell, D. B. (eds) 1997. *Plant Metabolism* (2nd edition). Longman, Essex, England.

Galston, A. W. 1989. *Life Processes in Plants*. Scientific American Library, Springer-Verlag, New York, USA.

Hooykaas, P. J. J., Hall, M. A. and Libbenga, K. R. (eds) 1999. *Biochemistry and Molecular Biology of Plant Hormones*. Elsevier, Amsterdam, The Netherlands.

Hopkins, W. G. 1995. *Introduction to Plant Physiology*. John Wiley & Sons, Inc., New York, USA.

Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. *Molecular Cell Biology* (4th edition). W.H. Freeman and Company, New York, USA.

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SUGGESTED READINGS (FOR LABORATORY EXERCISES)

Bajracharya, D. 1999. *Experiments in Plant Physiology: A Laboratory'Manual*. Narosa Publishing House, New Delhi.

Cooper, T. G. 1977. *Tools in Biochemistry*. John Wiley, New York, USA.

Copeland, R. A. 1996. *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis.* VCH Publishers, New York.

Dennison, C. 1999. *A Guide to Protein Isolation*. Kluwer Academic Publishers, Dordrecht, The Netherland.

Devi, P. 2000. *Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics*. Agrobios, Jodhpur, India.

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Harborne, T. C. 1981. *Phytochernical Methods: A Guide to Modern Techniques of Plant Analysis*. Chapman & Hall, London.

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Moore, T. C. 1974. *Research Experiences in Plant Physiology: A Laboratory Manual*. Springer-Verlag, Berlin.

Ninfa, A. J. and Ballou, D. P. 1998. *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*. Fitzgerald Science Press, Inc., Maryland, USA.

Plummer, D. T. 1988. *An Introduction to Practical Biochemistry*. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Scott, R. P. W. 1995. *Techniques and Practice of Chromatography*. Marcel Dekker, Inc., New York.

Wilson, K. and Goulding, K. H. (eds.), 1986. *A Biologists Guide to Principles and Techniques of Practical Biochemistry*. Edward Arnold, London, UK.

Wilson, K. and Walker, J. 1994. *Practical Biochemistry: Principles and Techniques*, 4th edition. Cambridge University Press, Cambridge, UK.

M.Sc. (Final) Botany Examination- 2016

Paper I

B-501: PLANT DEVELOPMENT AND REPRODUCTION

Unit 1: Introduction: Unique features of plant development, differences between animal and plant development. Seed germination and seedling development. Concept of stem cells in plants. Hormonal and environmental signaling and plant development. Shoot apical meristem (SAM) and development of shoot. Cell to cell communication. Cell fates and lineages. Regulation of tissue differentiation with special reference to xylem and phloem, secretory ducts and laticifers. Bud dormancy. Wood development in relation to environmental factors. Nodal anatomy of angiosperms.

Unit 2: Differentiation and development of Leaf. Phyllotaxy. Differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll. Metabolic changes associated with senescence and its regulation; influence of hormones and environmental factors on senescence. Root apical meristem (RAM) and development of root(s), lateral roots and root hairs. Hormonal control of root development.

Unit 3: Reproduction: Vegetative options and sexual reproduction; flower development; genetics of floral organ differentiation; homeotic mutants in *Arabidopsis* and *Antirrhinum*; sex determination in plants. Male gametophyte: Structure of anthers; microsporogenesis, role of tapetum; pollen development and gene expression; sperm dimorphism and hybrid seed production; pollen germination, pollen tube growth and guidance; pollen storage; pollen allergy; pollen embryos.

Unit 4: Female gametophyte: Ovule development; megasporogenesis; organization of the embryo sac, structure of the embryo sac cells. Pollination, pollen-pistil interaction and fertilization: Floral

characteristics, pollination mechanisms and vectors; breeding systems; commercial considerations; structure of the pistil; pollen-stigma interactions, sporophytic and gametophytic self-incompatibility in plants. Double fertilization and *in vitro* fertilization in plants.

Unit 5: Endosperm development during early, maturation and desiccation stages; embryogenesis, ultrastructure and nuclear cytology; cell lineages during late embryo development; storage proteins of endosperm and embryo; polyembryony; apomixis; embryo culture. Seed development and fruit growth: dynamics of fruit growth; biochemistry and molecular biology of fruit maturation. Seed dormancy: Importance and types. Basics of seed technology.

LABORATORY/FIELD EXERCISES

1. Effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
2. Role of dark and red light/far-red light on the expansion of cotyledons and epicotylar hook opening in pea.
3. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla*.
4. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus*, *Kalanchoe*, tobacco. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
5. Study of alternate and distichous, alternate and superposed, opposite and superposed; opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea, Mollugo, Raphanus, Hyoscyamus*, etc.) and induction of bolting under natural conditions as well as by GA treatment.
6. Microscopic examination of vertical sections of leaves such as *Cannabis*, tobacco, *Nerium*, maize and wheat to understand the internal structure of leaf tissues and trichomes, glands, etc. Also study the C3 and C4 leaf anatomy of plants.
7. Study of epidermal peels of leaves such as *Coccinia, Gaillardia, Tradescantia, Notonea*, etc. to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.
8. Study of whole roots in monocots and dicots. Examination of L.S. of root from a permanent preparation to understand the organization of root apical meristem and its derivatives (use maize, aerial roots of banyan, *Pistia, Jussiaea*, etc.). Origin of lateral roots. Study of leguminous roots with different types of nodules.
9. Study of microsporogenesis and gametogenesis in sections of anthers.
10. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa, Crotolaria, Tradescantia, Brassica, Petunia, Solanum melongena*, etc.).
11. Tests for pollen viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.
12. Estimating percentage and average pollen tube length *in vitro*.
13. Role of transcription and translation inhibitors on pollen germination and pollen tube growth.
14. Pollen storage, pollen-pistil interaction, self-incompatibility, *in vitro* pollination.
15. Study of ovules in cleared preparations; study of monosporic, bisporic and tetrasporic types of embryo sac development through examination of permanent, stained serial sections.

16. Field study of several types of flower with different pollination mechanisms (wind pollination, thrips pollination, bee/butterfly pollination, bird pollination).

17. Emasculation, bagging and hand pollination to study pollen germination, seed set and fruit development using self compatible and obligate outcrossing systems. Study of cleistogamous flowers and their adaptations.

18. Study of nuclear and celluar endosperm through dissections and staining.

19. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (*Syzygium cumini*), etc. by dissections.

20. Study of seed dormancy and methods to break dormancy.

SUGGESTED READINGS

Atwell, B. J., Kriedermann, P. E. and Jumbull, C. G. N. (eds) 1999. *Plants in Action: Adaptation in Nature, Performance in Cultivation*, MacMillan Education, Sydney, Australia.

Bewley, J. D. and Black, M. 1994. *Seeds: Physiology of Development and Germination*, Plenum Press, New York.

Bhojwani, S. S. and Bhatnagar, S. P. 2000. *The Embryology of Angiosperms* (4th revised and enlarged edition), Vikas Publishing House, New Delhi.

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Raghavan, V. 1999. *Developmental Biology of Flowering Plants*. Springer-Verlag, New York.

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Sedgely, M. and Griffin, A. R. 1989. *Sexual Reproduction of Tree Crops*. Academic Press, London.

Shivanna, K. R. and Johri, B. M. 1985. *The Angiosperm Pollen: Structure and Function*. Wiley Eastern Ltd., New York.

Shivanna, K. R. and Rangaswamy, N. S. 1992. *Pollen Biology: A Laboratory Manual*, Springer-Verlag, Berlin.

Shivanna, K. R. and Sawhney, V. K. (eds) 1997. *Pollen Biotechnology for Crop Production and Improvement*. Cambridge University Press, Cambridge.

Steeves, T. A. and Sussex, I. M. 1989. *Patterns in Plant Development* (2nd edition), Cambridge University Press, Cambridge.

The Plant Cell. Special Issue on Reproductive Biology of Plants, Vol. 5(10), 1993. The American Society of Plant Physiologists, Rockville, Maryland, USA.

Waisel, Y., Eshel, A. and Kafkaki, U. (eds) 1997. *Plant Roots: The Hidden Hall* (2nd edition), Marcel Dekker, New York.

SUGGESTED READINGS (FOR LABORATORY EXERCISES)

Chopra, V. L. 2001. *Plant Breeding: Field Crops*. Oxford Pvt. Ltd., New Delhi.

Chopra, V. L. 2001. *Plant Breeding: Theory and Practice*. Oxford IBH Pvt. Ltd., New Delhi.

Shivanna, K. R. and Rangaswamy, N. S. 1992. *Pollen Biology: A Laboratory Mannual*. Springer-Verlag, Berlin-Heidelberg (and references therein).

Paper II

B-502: PLANT ECOLOGY

Unit 1: Climate, Vegetation and Population Biology: Introduction to Concept, developments in ecology. Atmosphere, Hydrosphere and Biosphere- Life zones, major biomes, vegetation types of the world. Vegetation Organization: Concepts of community, analytical and synthetic characters, community coefficients, interspecific associations, ordination. Concept of habitat, coexistence and niche. Population Biology: Concepts and Growth models.

Unit 2: Ecosystem: Ecosystem: Structure and function. Energy dynamics- flow models and efficiencies. Mineral cycles: C, N, P and S mineral cycles, pathways, processes and budgets in terrestrial and aquatic systems. Global biogeochemical cycles of C, N, P and S. Productivity: Primary productivity- measurements, global pattern and controlling factors. Succession (Ecosystem development): Concept, mechanisms and models, changes in ecosystem properties during succession.

Unit 3: Soils and Mineralization: Soils: Characters, formation, classification and major soil types of the world. Soil quality assessment and factors affecting soil quality. Mineralization: Litter fall and decomposition- litter quality, climatic factors, soil microorganisms affecting mineralization. Nutrient synchronization and biological management of soil fertility.

Unit 4: Pollution and Climatic Changes: Air, water and soil pollution- kinds, sources, quality parameters, effects on plants and ecosystems. Bioremediation. Environment Impact Assessment. Climatic changes: Greenhouse gases; CO_2, CH_4, N_2O, CFCs – sources, trends and role; ozone layer and hole; consequences of climatic change – CO_2 fertilization; global warming, sea level rise and UV radiation. Concepts of Industrial Ecology.

Unit 5: Biodiversity, Ecosystem stability and Management: Biodiversity: concept and levels; biodiversity role in ecosystem functions and stability; speciation and extinction; IUCN categories of threat; distribution and global patterns; terrestrial biodiversity hot spots. Biodiversity status in India. Concept of ecosystem resistance and resilience; natural and anthropogenic ecological perturbations and their impact on plants and ecosystems. Ecosystem restoration. Ecology of plant invasion. Ecological management: Concepts of sustainable development; sustainability indicators.

LABORATORY/FIELD EXERCISES

1. To calculate mean, variance, standard deviation, standard error, coefficient of variation and to use t-test for comparing two means related to ecological data.
2. To prepare ombrothermic diagram for different sites on the basis of given data and to comment on climate.
3. To compute phenothermal indices for some desert plants
4. To find out the relationship between two ecological variables using correlation and regression analysis.
5. To determine minimum size and number of quadrates required for reliable estimate of biomass in a natural field.
6. To find out association between important species using Chi-square test.
7. To compare protected and gochar land vegetation using similarity indices.
8. To analyze plant communities using Bra-Curtis/Twin span ordination method.
9. To determine diversity indices (concentration of dominance, Shannon-Wiener, species richness, equitability and β diversity) for protected and gochar land vegetation.
10. To estimate IVI of the species in protected and gochar land vegetation
11. To determine productivity in terrestrial (CO_2 Analyzer) and aquatic (Light and dark bottle method) systems.
12. To determine organic carbon content in protected and gochar land soils.
13. To estimate chlorophyll content in SO_2 fumigated and unfumigated plant leaves.
14. To estimate rate of soil respiration by alkali absorption method.
15. To estimate percent loss of litter using litterbag method.
16. To study environmental impact of a given developmental activity using checklist as an EIA method.

SUGGESTED READINGS

Barbour, M. G., Burk, J. H. and Pitts, W. D. 1987. *Terrestrial Plant Ecology*. Bejamin/Cummings Publication Company, California.

Begon, M., Harper, J. L. and Townsend, C. R. 1996. *Ecology*. Blackwell Science, Cambridge, U.S.A.

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Cadish, G. and Giller, K. E. 1997. *Driven by Nature, Plant Litter Quality and Decomposition*, CAB International Wallingford, U.K.

Chapman, B. and Bilharz, S. 1997. *Sustainability Indicators*. John Wiley & Sons, New York.

Heywood, V. H. and Watson, R. T. 1995. *Global Biodiversity Assessment*. Cambridge University Press.

Hill, M. K. 1997. *Understanding Environmental Pollution*. Cambridge University Press.

Koromondy, E. J. 1996. *Concepts of Ecology*. Prentice-Hall of India Pvt. Ltd., New Delhi.

Ludwig, J. and Reynolds, J.F. 1988. *Statistical Ecology*. John Wiley & Sons.

Mason, C. F. 1991. *Biology of Freshwater Pollution*. Longman.

Muller-Dombois, D. and Ellenberg, H. 1974. *Aims and Methods of Vegetation Ecology*, Wiley, New York.

Odum, E. P. 1971. *Fundamentals of Ecology*, Saunders, Philadelphia.

Odum, E. P. 1983. *Basic Ecology*, Saunders, Philadelphia.

Smith, R. L. 1996. *Ecology and Field Biology*. Harper Collins, New York.

Treshow, M. 1985. *Air Pollution and Plant Life*. Wiley Interscience.

SUGGESTED READINGS (FOR LABORATORY EXERCISES)

APHA-*Standard Methods for the Examination of Water and Waste Water*. American Public Health Association, Washington, D.C.

Krebs, C. J. 1989. *Ecological Methodology*. Harper and Row, New York, USA.

Ludwig, J. A. and Reynolds, J. F. 1988. *Statistical Ecology*. Wiley, New York.

Magurran, A. E. 1988. *Ecological Density and its Measurement*. Chapman & Hall, London.

Misra, R. 1968. *Ecology Work Book*. Oxford & IBH, New Delhi.

Moore, P. W. and Chapman, S. B. 1986. *Methods in Plant Ecology*. Blackwell Scientific Publications.

Muller-Domois, D. and Ellenberg, H. 1974. *Aims and Methods of Vegetaion Ecology*. Wiley, New York.

Pielou, E. C. 1984. *The Interpretation of Ecological Data*. Wiley, New York.

Smith, R. L. 1996. *Ecology and Field Biology*. Harper Collins, New York.

Sokal, R. R. and Rohlf, F. J. 1995. *Biometry*. W.H. Freeman & Co., San Francisco.

Paper III

B-503: PLANT RESOURCE UTILIZATION AND CONSERVATION

Unit 1: Origin of agriculture: World centres of primary diversity of domesticated plants: The Indo-Burmese centre; plant introductions and secondary centres.
Green revolution: History of agriculture revolution, Wheat revolution in India, Strategies for further increasing production; Impact of green revolution, green revolution phase II.
Innovations for meeting World food demands. New dimensions of agricultural policy, research and education.
Regimes of WTO and plant genetic resources of India.

Unit 2: Important fire-wood and timber yielding plants with special reference to Rajasthan desert. Non-wood forest products (NWFPs). Bamboos: distribution, cultivation and economic uses. Rattans. Raw materials for paper making. Gums, resins, dyes and tannins from natural plant resources.

Unit 3: Origin, botany, cultivation and uses of (i) Food, forage and fodder crops, (ii) Fiber crops, (iii) Medicinal and aromatic plants, and (iv) Vegetable and oil-yielding crops. Plants used as avenue tree for shade, pollution control and aesthetics.

Unit 4: Basic statistics: Central tendency, dispersion, standard error, coefficient of variation; Probability distributions (normal, binomial of Poission), Confidence limits, Test of statistical significance (t-test; Chi-square). Analysis of variance. RBD and its application in plant breeding and genetics; Correlation and Regression. Computer application in data analysis.

Unit 5: Strategies for conservation- *in situ* conservation: International efforts and Indian initiatives, protected areas in India- sanctuaries, national parks, biosphere reserves, wetlands, mangroves and coral reefs for conservation of wild biodiversity. Strategies for conservation- *ex situ* conservation: Principles and practices, botanical gardens, field gene banks, seed banks, *in vitro* repositories, cryobanks; General account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific & Industrial Research (CSIR), and the Department of Biotechnology (DBT).

The practical exercises are divided into three units: (1) Laboratory work, (2) Field survey and (3) Scientific visits.

(1) LABORATORY WORK

1. Quantification of starch in food crops (wheat, rice, maize, potato & sweet potato).
2. Quantification of starch in forage/folder crops (sorghum, bajra, gram & guar bean).
3. Quantification of acid detergent fiber (ADF) content in fiber crops (cotton, jute, coir & silk cotton)
4. Morpho-anatomical features of plant fibers (cotton, jute, coir & silk cotton).
5. Quantification of acid, iodine and saponification values in vegetable oils.
6. Micro-chemical test for fats & oils, gums, tannins and dyes.
7. Impurity test for natural products (honey, saffron & mustard oil).
8. Specimen identifications:

   Food crops: wheat, maize potato, chickpea, sugarcane & sweet potato

   Forage/Fodder crops: sorghum, bajra, gram & guar bean

   Fiber crops: cotton, jute, coir & silk cotton

   Medicinal plants**:** *Papaver, Catharanthus, Adhatoda, Allium, Rauvolffia, Withania, Phyllanthus & Aloe*

   Aromatic plants: *Mentha, Rosa, Majorana, Jasminum, Cymbopogon* & *Pandanus*.

9. Distribution pattern of a biological character in a population.
10. Measurement of central tendency (mean, variance & standard deviation).
11. Analysis of variance (RBD, split & strip).
12. Estimation of pcv, gcv, heritability and genetic advance using RBD analysis.
13. Students t-test for comparison of means.
14. Correlation and testing deviation of correlation coefficient.
15. Regression and confidence limits.

(2) FIELD SURVEY

Firewood and timber-yielding plants and NWFP's

a) Prepare a short list of 10 most important sources of firewood and timber in your locality. Give their local names, scientific names and families to which they belong. Mention their properties.

b) A survey of a part of the town or city should be carried out by the entire class in batches. Individual student will select one avenue/road and locate the trees planted on a graph paper. They will identify the trees, mention their size, canopy shape, blossoming and fruiting period and their status (healthy, diseased, infested, mutilated, misused or dying) and report whether or not the conditions in which they are surviving are satisfactory. The individual reports will be combined to prepare a larger map of the area, which can be used for subsequent monitoring either by the next batch of students/teachers/local communities/NGO's/or civic authorities.

The purpose of exercise in item (b) above is to make the students aware of the kinds of trees and value in urban ecosystems and ecological services.

(3) SCIENTIFIC VISITS*

The students should be taken to one of the following:

i A protected area (biosphere reserve, national park, or a sanctuary)
ii A wetland
iii A mangrove
iv National Bureau of Plant Genetic Resources, New Delhi – 110012 or one of its field stations
v Headquarters of the Botanical Survey of India or one of its Regional Circles
vi A CSIR Laboratory doing research on plant and their utilization
vii An ICAR Research Institute or a field station dealing with one major crop or crops
viii A recognized botanical garden or a museum (such as those at the Forest Research Institute, Dehradun; National Botanical Research Institute, Lucknow; Tropical Botanical Garden and Research Institute, Trivandrum), which has rich collection of plant products.

* Note: The students are expected to prepare a brief illustrated narrative of the Scientific Visits. After evaluation, the grades awarded to the students by the teachers should be added to the final assessment of the practical examination.

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Paper IV

B-504: BIOTECHNOLOGY AND GENETIC ENGINEERING OF PLANTS AND MICROBES

Unit 1: Biotechnology: Basic concepts, principles and scope. Plant Cell and Tissue Culture: General introduction, history, scope, concept of cellular differentiation, totipotency. Fundamental of Plant Morphogenesis, plant regeneration, cultured cell/tissue through somatic embryogenesis and organogenesis. Production of hybrids in plants and somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration.

Unit 2: Recombinant DNA technology: Extraction, purification and quantification of genomic and plasmid DNA; enzymes for cutting and joining of DNA and their mode of action. Cloning vectors: based on plasmids, bacteriophages, yeast, and plants. c-DNA libraries. Oligonucleotide synthesis. Sequencing of DNA: Chain termination, capillary electrophoresis and pyrosequencing. PCR: History, designing of primers, optimization, and applications. DNA fingerprinting and their applications.

Unit 3: Genetic engineering of plants: Aims, strategies for development of transgenics. *Agrobacterium* – the natural genetic engineer, T-DNA and transposon mediated gene tagging. Production of transplastomic plants and their utilization. Cisgenesis. Microbial genetic manipulation: transformation, transfection and selection of recombinant bacteria and bacteriophages. Introduction of DNA in yeast, fungi and plant. Genetic improvement of industrial microbes and nitrogen fixers. Fermentation technology: fundamentals and industrial applications.

Unit 4: Genomics and proteomics: Genetic and physical mapping of genes. Molecular markers and their applications in characterization of genes/germplasm and for introgression of useful traits. Artificial chromosomes and their uses. High throughput and ultra-high throughput sequencing. Genome projects. Bioinformatics and its applications. Functional genomics and microarrays. Proteomics-Protein profiling and its significance.

Unit 5: Applications of plant tissue culture: Clonal propagation, artificial seed, production of hybrids and somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm storage. Applications of recombinant DNA technology. Intellectual property rights, possible ecological risks and ethical concerns.

LABORATORY EXERCISES

1. Growth characteristics of *E. coli* using plating and turbidimetric methods.
2. Isolation of plasmid from *E. coli* by alkaline lysis method and its quantification by spectrophotometry.
3. Restriction digestion of the plasmid and estimation of the size of various DNA fragments.
4. Cloning of a DNA fragment in a plasmid vector, transformation of the given bacterial population and selection of recombinants.
5. Demonstration of DNA sequencing by Sanger's dideoxy method.
6. Isolation of protoplasts from various plant tissues and testing their viability.
7. Effect of physical (e.g. temperature) and chemical (e.g. osmoticum) factors on protoplast yield.
8. Demonstration of protoplast fusion employing PEG.
9. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seed.

10. Demonstration of androgenesis in *Datura*.

11. Electroporation of protoplasts and checking of transient expression of the reporter gene.

12. Co-cultivation of the plant material (e.g. leaf discs) with *Agrobacterium* and study GUS activity histochemically.

SUGGESTED READINGS

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Glick, B. R. and Thompson, J.E. 1993. *Methods in Plant Molecular Biology and Biotechnology*. CRC Press, Boca Raton, Florida.

Glover, D. M. and Harnes, B. D. (eds) 1995. *DNA Cloning: A Practical Approach. Core Techniques*, 2nd edition, PAS, IRL Press at Oxford University Press, Oxford.

Hackett, P. B., Fuchs, J. A. and Messing, J. W. 1988. *An Introduction to Recombinant DNA Techniques: Basic Experiments in Gene Manipulation*. The Benjamin/Cummings Publishing Co., Inc Menlo Park, California.

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Shaw, C. H. (ed.) 1988. *Plant Molecular Biology: A Practical Approach*. IRL Press, Oxford.

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Paper V (ELECTIVE)

B-505: STRESS BIOLOGY

Unit 1: Plant response to abiotic stresses: Types of stresses, early adaptive response to water deficit and salinity. Photo-inhibition and other physiological activities affected by stress. Structure and processes affected by desiccation. Oxidative stress and anti-oxidant system in plants.

Unit 2: Abiotic and biotic stress signaling in plants. Stress sensor, role of MAP Kinases, and Calcium calmodulin in stress sensing. ABA dependent and ABA independent pathways. Ionic and osmotic sensing signaling mechanism (SOS salt overlay pathways). Biotic stress signaling (plant defense): Role of Jasmonic acid, salicylic acid, ethylene and nitric oxide signaling in plant defense.

Unit 3: Strategies and Mechanisms of stress tolerance: Biochemical and molecular basis of water deficit and salt tolerance in plants. Salinity tolerance determinants (effectors and regulatory molecules). Strategies to improve crop plants for stress tolerance (water deficit, salinity and low and high temperature stress) using transgenic plants.

Unit 4: Stress Proteins: Genes regulated by environmental stress. Structure and functions of some important stress proteins (HSPs, ANPs, PR proteins, LEA proteins, aquaporines, osmotin, systemines, defensins, ubiquitins).

Unit 5: Plant growth regulators and stress: Role of PGRs in mitigation of stress. Role of ABA, Ethylene, Polyamines, Salicylic acid and Jasmonic acid.

LABORATORY EXERCISES

1. Estimate free amino acids content in the given sample.

2. Estimate proline content in given water stressed samples.
3. Estimate betaine content in salt stressed samples.
4. Find out the ascorbic content in temperature (low and high) and salt stressed samples.
5. Find out the concentration of polyamines in the given stressed samples.
6. Effect of stress on the activity of following scavenging enzymes: (a) superoxide dismutase, (b) catalase, (c) peroxidase, (d) ascorbate peroxidase.
7. Visualization of stress proteins by SDS-gel electrophoresis.
8. Effect of stress on membrane damage in relation to lipid peroxidation.
9. Effect of water stress and Hyperthermia on the activity of nitrate reductase.

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Paper – V (ELECTIVE)

B-506: WEED BIOLOGY

Unit 1: Weed Biology: Definition, scope, characteristics and classification of weeds, important weeds associated with different crops. Principles of weed ecology– Environment, succession niche differentiation, r and k selection, C, R & S selection, plant demography and population dynamics. Genetics and evolution in weeds– Breeding systems in weeds, weeds as strategists, influence of humans on weed evolution. Weed seed dynamics germination and establishment.

Unit 2: Weed Crop Interference: Competition– Definition components, factors favoring crop in competition, critical period, competition models– additive, replacement, simulation and diffuse, physiological aspects of competition.

Unit 3: Allelopathy: Allelopathy: Definition, characteristics, mode of release, chemical nature, allelopathy in weed crop system management. Forms of positive interference: Commensalism, Protocooperation, Mutualism and Facilitation.

Unit 4: Agroecology: Concept of agroecology, organic farming– characteristics and constraints, cropping systems and yield advantages. Tillage and weed control, application of ecological principles in weed control. Sociological aspects of weed control. Assessment of weed infestation. Methods of weed control– biological, physical and chemical. Weed control practices in India.

Unit 5: Herbicide: Introduction, nomenclature, classification, chemistry, properties, formulations, application equipments. Foliar and soil applied herbicides, Physiology of herbicide, Mode of action, translocation. Influence of environmental factors on herbicide metabolism. Toxicology and hazards.

LABORATORY/FIELD EXERCISE

1. To identify weeds of cultivated fields with nomenclature.
2. To determine weed species dominance, diversity and evenness.
3. To study dominance-diversity curves of vegetation.
4. To determine distribution pattern of weeds.
5. To determine soil seed reserve for weeds.
6. To determine total nitrogen, available phosphorus and exchangeable potassium in field soils.
7. To learn sampling techniques for weed-crop in fields.
8. To determine biomass, standing state of crop-weed in fields.
9. To determine the effect of herbicide on chlorophyll and soluble protein in weeds.
10. To determine microbial decomposition in herbicides (soil applied) fields.
11. To determine microfungal biomass in herbicide applied fields.
12. To learn the use of single factor design: layout and analysis.
13. To calibrate sprayer on the basis of output and speed of the applying/carrying equipment.
14. To predict grain yield, loss by weed infestation/ gain by management.

SUGGESTED READINGS

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Rose, M. A. and Lambi, C. A. 1985. *Applied Weed Science*. Burgess Publishing Co., Minnesota.

Sen, D. N. 1981. *Ecological Approaches to India Weeds*. Geobios International, Jodhpur.

Zimdahl, R.L. 1980. *Weed Crop Competition– A Review*. International Plant Protection Centre, Corvallis, USA.

Paper – V (ELECTIVE)

B-507: POPULATION BIOLOGY AND DESERT ECOLOGY

Unit 1: Population: Concept in population biology, Darwin theories of Evolution: Population grown models. Density–independent, density–dependent. Population genetics: Gene frequencies- Hardy Weinberg principle; Genetic variations of population: Polygenetic inheritance; Quantitative genetics and heritability. Human population: Growth, Environment and Development.

Unit 2: Demography: Plant demography and population dynamics. Life tables and their components; Regulation of plant population; Interaction in mixture of species. Competition: components, characters favouring success, models; Allelopathy; mode of release, allelochemicals and their role in natural ecosystems; Coexistence and niche; Evolution of mutualism– Basic models; Evolutionary ecology.

Unit 3: Sand dunes and their management and Indira Gandhi Canal: Sand dunes: classification, stabilization and management, wind breaks and shelter belts, afforestation and desert control measures. Drought: definition, types, implication and management techniques; Indira Gandhi Canal and its ecological implications.

Unit 4: Saline habitats, Wastelands and Wetlands: Inland Saline: Habitat and vegetation characteristics, germination, growth and survival adaptations. Wasteland development: definition, nature and characteristics of wasteland. Wastelands in Rajasthan.

Wet lands: Introduction, characteristics, distribution in world, wetlands in India and their importance.

Unit 5: Desert vegetation and Resources: Introduction to World Desert biomes; Origin, characters and Geomorphology of Thar desert; Vegetation and floral composition of the Rajasthan desert; Adaptations of plants matching the desert environment; Effect of biotic factors on desert vegetation; Thar Desert Resources: Forest energy, minerals, live stocks and rangeland conditions, Ecology of grazing lands and impact of over-grazing, Threatened plants of Rajasthan desert and their conservation strategies.

LABORATORY/FIELD EXERCISES

1. Measurement of growth fitting the growth curve and estimating specific growth rate:
    a. Soil fungi
    b. For any two wild weedy annual species
2. Measurements of seed output and reproductive capacity of some desert annuals.
3. Rate of seedling natality and mortality for two weedy dicots.
4. Dominance, diversity and evenness measurements of desert vegetation.
5. Measurement of niche width for trees/shrubs/annuals.
6. Gene frequency for a character in tree/shrub seedlings.
7. Estimation of notability using ANOVA (RBD) tool.
8. Seed to seedling character relationships.
9. Stomata size, opening rhymes and density in two well adapted desert plants.
10. Measurement of water loss and relative water content in desert plants.
11. Measurement of succulence in desert halophytic plants.
12. Measurement of soil salinity in Thar desert.

13. Quantification of ions (Na, Cl) concentrations in halophytes.
14. Quantification of proline concentrations in plants of desert/haloxeric environment.
15. Measurement of gochar land carrying capacity for farm animals.

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Krebs, C. J. 1989. *Ecological Methodology*. Harper and Row, New York, USA.

Ludwig, J. A. and Raynolds, J.F. 1988. *Statistical Ecology.* Wiley, New York.

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Sen, D. N. 1990. *Ecology and Vegetation of Indian Desert* (eds.). Agro Botanical Publishers, India.

Singh, R. P. and Singh, S. 2001. *Sustainable Development of the Indian Arid zone – A Research Perspective* (eds.). Scientific Publishers, Jodhpur.

Paper V (ELECTIVE)

B-508: SEED PATHOLOGY

Unit1: History of seed pathology and importance, principles and methods of seed health testing, seed borne inoculum, important diseases caused by seed borne pathogens.

Unit2:Morphology and anatomy of seed in relation to invasion and location of pathogen, mechanismofseedinfection,factorsaffectingseedinfectionanditsestablishment,location of infection in seed.

Unit3:Seed transmission of seed born pathogen, method of detection ,factors affecting transmission of seed borne pathogens, longevity of seedborne pathogens ,control of seed borne pathogens, principles of controls.

Unit4:Storage fungi, mode of seed deterioration, mycotoxine laboration, detection of mycotoxins, effects of mycotoxins on animal and human health, management of mycotoxin contamination of seeds. Insects in relation to losses in stored grains and their management.

Unit 5: Seed treatment: Physical, chemical and biological. Quarantine and seed laws. Identification of seed born fungi with special reference to desert food crops. Seed born bacteria and viruses. Importance of seed born microorganisms. Seed certification.

LABORATORYEXERCISE

1. Dryseedsamplesfordeterminingpercentageofnormal&modifiedorsymptomatic seeds.
2. Seedwashingtesttodetermineseedborneinoculumandtocalculatethesporeload using haemocytometer.
3. Seedbornemycoflorabystandardblottermethodofsomerepresentativecropsof different groups.
4. Seed borne mycoflorausing potato dextrose agar plate method.
5. Effectofclorinepre-treatmentonseedbornemycoflorainstandardblottermethod.
6. Seedbornemycoflorausing2,4-Dblotter and deep freeze methods.
7. Location of pathogen in infected seeds by clearing and whole mount preparation of seed parts.
8. Location of infection in seed through hand section and prepared microtome slides.
9. Detection of Micoflora of stored seed samples by SBP and PDA methods.
10. Detection of Aflatoxin contamination in stored seed sample by UV fluorescence light.
11. Moisture content of seed using oven and any other method.
12 .Determination of enzymatic activity during germination.
13.Seed adulterants,identificationofadulterants,effectsofadulterantsonthefoodvalue.
14.Bacterial symptoms in seeds of local crops.
15.Bacterial symptoms caused during germination of seed and seedling.
16. Isolation and culture of seed borne bacteria, use of staining techniques to study the morphology.
17.Symptoms caused by nematodes on seed using specimens.
18.Common methods of physical, chemical and biologicalcontrol.
19.Testing of vegetatively propagated plant parts used as seeds for the associated microorganisms.

SUGGESTEDREADINGS

Agarwal,V.K.and Sissclair,J.B.1993.*PrinciplesofSeedPathology*,Vol.I&II.CBS PublishersandDistributers.

Agrios,G.N.1997.*PlantPathology*.AcademicPress, London and NewYork.

Jha D.K., A text book of seed pathology, Vikas publication house , New Delhi.

Neergaard,P.1979. *Seed Pathology*,Vols.I&II.The Macmillan Pres Ltd., London.

Singh,T.and Trivedi, P.C.1994.*VistasinSeedBiology*.(Edited)Vols. I & II. Printwell, Jaipur and Hyderabad.

Suryanarayana,D.1978. *Seed Pathology*.VikasPublishingHousePvt.Ltd.

Paper V (ELECTIVE)

B-509:INDUSTRIAL MICROBIOLOGY

Unit1: Definition, scopeandhistoricaldevelopmentofIndustrialmicrobiology.Fermentors: (Bioreactor)construction, Type, operation and basic functions. Development of Industrial fermentation process: Screening –Primary and Secondary, Fermentation Products, Stock Cultures, Fermentation media, Biological waste treatment.

Unit2: Dairy and Food Microbiology: Milk: composition, constituents , Processing , Pathogen , Pasteurization ,grading of milk, - Diary products :Cheese,Y ogurt, Cream, Buttermilk, Food Microbiology : Fermented vegetables: Sauerkrant, Kumis, Food borne illness , microbial spoilage , food preservation.

Unit3: Industrialproduction:Alcohol,Beer,Wine,Vinegar,Citricacid,Vitamins,enzymes,steroids, Vaccines. Antibiotics: Classification mode of action, commercial production, Penicillium and streptomycin. Sensitivity and non–Medicaluses.

Unit 4: Industrial Production of Biofertilizer: Present position and future, Nitrogen fixing Biofertilizer*,RhizobiumAzospirillum*and*Azatobactor.*Plantgrothpromoting *Rhizobacteria*, Blue green algae and *Azolla*. Phosphate mobilizing Biofertilizers. Biopesticides. Bioherbicides, Plant incorporated protectants (PIPs) Role of EPA (Environmental Protection Agency).

Unit 5: Biofuel: Biogas production, Biofilm, Biochip, Biosensor and Biosurfactants. Biosorption, Bioremediation, Bioleaching, Textile microbiology: (Cottonandwool), Petroleum microbiology, wood microbiology and Leather Microbiology.

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LABORATORYEXERCISE

1. Microscopic measurements.
2. Preparation of culture media.
3. Preparation of bacterial stains.
4. Culturing of microorganisms and cultural characteristics of bacteria.
5. Motility of bacteria by hanging drop method.
6. Study of some important industrially important genera of fungi.
7. Staining of bacteria–Simple stain, Gram's stain,&negative staining.
8. Cultivation of Nitrogen fixing Biofertilizers–*Rhizobium, Azospirillum, Azatobacter*.
9. Oligodynamic action of heavy metals.
10. Antibiotic sensitivity test by agar disc diffusion and tube dilution methods.
11. Isolation & identification of Mycorrhizal fungi from Rhizosphere soil.
12. Enzymatic test of Milk by Methyl Blue Reductase Test.
13. Effect of various factors on the growth of microorganisms(pH,temp,UV light)
14. Metabolism of microorganisms–carbohydrate fermentation, hydrolysis of starch urea and gelatin.

15. Microbiological analysis of food product.
16. Presumptive test of coliform group of bacteria.

Suggested Reading:

Casida,L.E. *Industrial Microbiology*. John Wiley and

sons.Chum. *Microbiology*. JohnWiley&Sons.

Corum,C.J.*Development of Industrial Microbiology*. American Institute of Bio.Sci.

Dube .C.,and Maheshwari D.K. , A Text Book of Microbiology , S.chand and co. Ltd

Dube R.C..,and Maheshwari D.K. , Practical Microbiology , S. Chand and co. Ltd

Kaushik,P. *Microbiology*. Emkay Pub., NewDelhi.

Pelczer, M.J., Chau, E.C.G. and Krieg, N.R. *Microbiology Concepts and application*. McGraHill.

Power,C.B. and Daginawala, H.F.*General Microbiology*. Himalaya

Pub.House.Prescott,S.C.andDunn,C.G.*IndustrialMicrobiology*.McGrawHillPub.

Robert F. Boyd. *General Microbiology*.Times Mirror Publishers.
Salle,A.J.*Fundamental & Principles of Bacteriology*. Tata McGRaw Hill.

Sivakumar P.K. , Joe MM, Sukesh K , An Introduction to Industrial

Microbioloy , Pub.: S.Chand and co. Ltd

Spencer,J.E.T.andSpencer,D.M.*YeastTechnology*.Springer-Verlag.

Staubury,P.F.andWhiterker,A.*PrinciplesofFermentationTechnology*.PergamonPress.

Thoma,R.W.*IndustrialMicrobiology*.Hutchinson&Ross.

Tortora,G.J.,Funke,B.R. andCasechristive:*Microbiology*.BengaminPublishingCo.

Paper V (ELECTIVE)

B-510: MOLECULAR BIOLOGY AND PLANT BIOTECHNOLOGY

Unit 1: Techniques of Molecular Biology. Nucleic acid: electrophoresis, restriction endonucleases, DNA hybridization, DNA cloning and libraries, PCR, shotgun and paired end strategies of genome assembly and genome wide analysis. DNA sequencing. Proteins: purification from cell extracts, separation on polyacrylamide gels, immunoblotting, protein sequencing.

Unit 2: Gene expression and function: Study of transcript of cloned gene, regulation of gene expression, translation product of cloned gene their identification and protein-protein interaction. Regulation of transcription in prokaryotes and eukaryotes. Regulation of translation in prokaroyates and eukaryotes. Directed mutagenesis and protein engineering. Basic principles and applications of microarray.

Unit 3: Cell cycle and its regulation. Tissue specific gene expression, genomes responding to phytohormones, phytochromes, microbial infections and selected stresses. Homeotic mutants. Ribozymes and antisense technology.

Unit 4: Applications of plant biotechnology and genetic engineering: Plant cell culture and somatic cell genetics as non-conventional methods of plant improvement. Development of pathogen and herbicide resistant, stress and senescence-tolerant plants. Modification of plant nutritional contents. Plants as bioreactors. Genomics: Comparative, functional and structural. Molecular markers for genome analysis and applied plant breeding. Proteomics: basic methods and tools of protein profiling and its applications.

Unit 5: Biotechnology as related to society: ethics, environmental safety, biodiversity and genetic resources. Safety measures, risk assessment and good laboratory practices. IPR and WIPO. Plant breeder's and farmer's rights. Development of biotechnology in India. Terminator and Traitor technology. Biosensor technology: principles and applications.

LABORATORY EXERCISE

1. Selection of explants, surface sterilization and inoculation to initiate cultures of tobacco/cereals/legumes.
2. Studies on effects of plant growth regulators on cell, tissue and organ culture.
3. Study of parameters of tissue growth in culture (i) Fresh weight, (ii) Dry weight, (iii) Cell number, (iv) Protein contents, and (v) Carbohydrate contents.
4. Differentiation of tissue through organogenesis/somatic embryogenesis. Microscopic studies and photomicrography
5. Experiments on rejuvenation and multiple shoot induction from mature nodal shoot segments of trees/horticultural/floricultural crops.
6. Encapsulation of somatic embryos/buds using alginate.
7. Isolation of protoplasts from leaf/suspension culture. Purification of protoplasts. Culture of protoplast.
8. Experiments on fusion of plant protoplasts using polyethylene glycol (PEG) electrofusion of plant protoplast.
9. Experiments on root induction from cultured shoots.
10. Extraction of genomic DNA from *in vitro* raised tissue/plants.

11. Quantity and quality check of DNA samples, using spectrophotometric and electrophoretic methods.
12. Biochemical/molecular analysis of plant tissue culture of various stages of development using polyacrylamide gel electrophoresis (protein/isoenzymes).
13. Use of spectrophotometry/spectrofluorimetry for plant tissue analysis
14. Ultrafilteration techniques.
15. Analysis of tissue for secondary metabolites using TLC/spectrophotometry.
16. Biosafety measures/IPR/patents.
17. Experiments on transformation of plant tissues.
18. Bioinformatics.

SUGGESTED READINGS

Weaver, R. F. and Hedrick, P. W. 1992. *Genetics* (2nd ed.). Dubuque, IA: Wm. C. Brown Publishers.

Pauline, M. D. 1997. *Hairy Roots: Culture and Applications*. Harwood Academic Publishers.

Peter, C. and Rolf, B. 2000. *Computational Molecular Biology: An Introduction*. John Willey & Sons Ltd.

Phillips, R. L. and Vasil, I. K. 1994. *DNA- Based Markers in Plants*. Kluwer Academic Publishers.

Schena, M. 1996. *DNA microassays (A Practical Approach).* Oxford University Press.

Woung-Young, S. and Bhojwani, S. S. 1999. *Morphogenesis in Tissue Cultures* (ed.). Kluwer Academic Publisheres.

Paper V (ELECTIVE)

B-511: Plant Microbe-Interactions (PMIs)

Unit 1: **Biotic Interactions:** Biology of plant-microbe interactions. Concepts of competition, commensalisms, mutualism, parasitisms and symbiosis. Evolution of parasitism and symbiosis. Endosymbiosis theory. Gene for gene concept for interaction to integration of partners. Super-organism genetic system. Common host mechanisms. Dynamics of plant responses to microbes, and evolution of susceptibility and resistance.

Unit 2: **Symbiotic and non-symbiotic interactions:** Legume-rhizobia, Actinorhizal plants and *Frankia*, Plant- Mycorrhizal and other types of symbiosis. Plant and bacterial factors in RN symbiosis. Nitrogen fixation in extreme environment. Bacterial endophytes in cereals and their significance (*Herbaspirillum, Gluconacetobacter, Azorcus, Burkholderia*). Symbiotic genes in rhizobia, *Frankia* and Mycorrhiza. Plant nutrient transporters for AM fungi (AM inducible Ammonium transporters). Plant Mycorrhizal association in desert plants. Applications of symbiotic and Plant growth promoting bacteria and Mycorrhiza.

Unit 3: **Plant and pathogen (Plant Diseases)**: Pathogenic plant microbe interaction; History and basic procedure of diagnosis of diseases; disease development; effect of pathogen on plant physiology; genetics

of plant diseases; plant defense against pathogens; control of plant diseases; major plant diseases caused by bacteria, virus and fungus. Plant- virus/viroid/phytoplasma interactions. Multitrophic interactions (pathogens, insects, nematodes, endophytes, parasitic plants). Biocontrol of diseases. Bacterial *hrp* and avirulence genes.

Unit 4: **Molecular basis of plant microbe interactions and signaling:** Molecular basis of symbiosis and pathogenesis, *Agrobacterium* and *Pseudomonas* – tomato system. Host inducible regulation. Hypersensitive reactions and PCD in plant pathogen interaction. Bacterial quorum sensing and biofilms. Plant-microbe communications during symbiosis. Bacterial secretary systems- Type- I, II and III. Bacterial mutants of N fixation defects (Hyper nodulation).

Unit 5: **Genomics of model legumes, microsymbionts, plant pathogens:** Brief account of model legumes and model RNB and their genomics. Genomes of selected bacterial endophytes, plant bacterial and fungal pathogens and PGP bacteria. Comparative genomics. Community and genome based views of plant–associated bacterial interactions. Metagenomics. Rhizosphere.

LABORATORY EXCERCISES

1. Preparation of culture media (TY, YEMA, LB)

2. Isolation of bacteria from various sources (root nodules, roots and stems and phyllosphere).

3. Methods of culturing bacteria

4. Purification of bacterial isolates

5. Motility test of bacteria by hanging drop method

6. Preservation of bacterial cultures (short term and long term)

7. Phenotypic characterization of bacterial isolates

(i) Intrinsic antibiotic resistance (IAR) pattern

(ii) NaCl tolerance

(iii) Acid alkali production

(iv) High temperature tolerance

(v) Carbon utilization profile

8. Biochemical characterization of bacterial isolates

(i) H_2S production

(ii) Indole production

(iii) Oxidase activity

(iv) Ammonia production

9. Metabolism of microorganisms-hydrolysis of starch, urea and gelatin

10. Demonstration of phosphate solubilization by bacterial isolates using PVK medium

11. Study of types of root nodules/morphology/anatomical preparation showing infection zone etc.

12. Isolation and identification of mycorrhizal fungi from rhizosphere soil

13. Calculation of percentage root colonization by mycorrhizae

14. Preparation of bacterial cell templates for amplification of DNA/genes through PCR

15. Amplification of 16S rRNA gene of bacterial isolates using PCR

16. Assessing genetic diversity in bacterial isolates by primer based amplification through PCR or performing amplified rDNA restriction analysis (ARDRA)

17. Tagging of root nodule bacteria with GUS gene and screening of GUS transconjugants

18. *In-vitro* inoculation studies using GUS tagged RNB strains

19. Performing GUS histochemical staining for localization of GUS tagged bacteria within root nodule

SUGGESTED READINGS

Bergey's Manual of Systematic Bacteriology. Second Edition. Volume Two (The Proteobacteria). Springer.

Boyd, R. F. 1984. *General Microbiology*. Times Mirror Publishers, New Delhi.

Chandra, S. and Kehri, H. K. 2006. *Biotechnology of VA Mycorrhizae*: *Indian Scenario*. New India Publishing Agency, New Delhi.

Dilworth, M. J., James, E. K., Sprent, J. I. and Newton, W. E. 2008. *Nitrogen-fixing Leguminous Symbioses*. Springer.

Pawlowski, K. and Newton, W. E. 2008. *Nitrogen-fixing Actinorhizal Symbioses*. Springer.

Pelczar, M. J., Chau, E. C. G. and Krieg, N. R. 1993. *Microbiology concepts and application*. McGraw Hill, New Delhi.

Power, C. B. and Daginawala, H. F. 1992. *General Microbiology*. Himalaya Pub. House, New Delhi.

Prescott, S. C. and Dunn, C. G. 1993. *Industrial Microbiology*. McGraw Hill Pub., New Delhi.

Salle, A. J. 2004. *Fundamental & Principles of Bacteriology*. Tata McGraw Hill Pub., New Delhi.

Smith, S. E. and Read, D. J. 1997. *Mycorrhizal Symbiosis*, Third Edition. Academic Press, London.

Somasegaran, P. and Hoben, H. J. 1994. *Handbook of Rhizobia* (*Methods in Legume-Rhizobium Technology*). Springer-Verlag.

Sprent, J. I. 2001. *Nodulation in legumes*. Kew Publishing.

Stéphane, D., Georges, S. D. and André, F. J. 2005. *In Vitro Culture of Mycorrhizas*. Springer.

Tiwari, M. and Sati, S. C. 2008. *The Mycorrhizae: Diversity Ecology & Applications*. Daya Publisher, New Delhi.

Vincent, J. M. 1970. *A manual for the practical study of the root nodule bacteria*. Blackwell Scientific Publications.