DEPARTMENT OF BOTANY

SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE

M.Sc. Botany Syllabus

Based on National Education Policy 2020 (NEP)

(To be implemented from Academic Year 2023-24)

July 2023

1. Title of the Course: M.Sc. Botany
2. Faculty: Science and Technology
3. Implementation period: For M.Sc. Part-I: August 2023 onwards
   For M.Sc., Part-II: August 2024 onwards
4. Preamble:

Plants have been significant throughout the history of human evolution. Botany, a branch of science, helps us understand the plant kingdom. The human population has been projected to reach 9 billion in the year 2045. The study of plants has therefore become paramount with reference to their utilization as food and medicine. 'Botany with a twist' would be the new *mantra*. Climate change and urbanization has influenced fisheries, animal husbandry, agriculture, and forest produce. Water shortages, pollution, and irregular monsoons added, make the future implications appear bleak. Currently, only 12 plants under cultivation account for 75% of all the human calories. However, there are about 5,500 different varieties of edible plants. Botanists need to study these plants and use them to their utmost potential by gaining theoretical and applied knowledge. Integrating classical and modern botany to solve problems faced by the real world is a new challenge.

The M.Sc. (Botany) syllabi has been redesigned under the aegis of the National Education Policy (2020). Major emphasis has been laid on skill development through hands-on training. Industry and entrepreneurship-oriented skills have been emphasized. The teaching-learning process has been enhanced in a wholesome manner and novel examination and evaluation parameters have been included. On-Job-Training (OJT) has been made mandatory. This will allow students to be aware of on-ground realities and requisites from their first semester of the master's program. For example, during this training, students can directly interact with businessmen/technocrats. It is also envisaged that through these meaningful interactions, many students will develop interest to pursue their Ph.D. degrees.

The curriculum has a judicious mix of 'core' courses essential to understand the 'essence' of botany and a number of 'elective' courses. The 'core' courses involve taxonomy of lower and higher forms, plant biochemistry and physiology, plant genetics, plant development, plant ecology, plant cell and molecular biology and a number of 'electives' spanning across botany and its interfaces with various disciplines as outlined in the structure to cover skill-based and applied aspects of botany.

This structure would help students align to the latest trends in research and technology at the interphase of agriculture, environmental sciences, pharmaceutical sciences and genetic engineering. This would attract students towards pure science disciplines and further help enhance their employability skills. The NEP structure envisages that a student can select 'elective' courses across any discipline and we feel that this would help break the silos and invigorate 'botany' as a whole, fostering many inter-disciplinary collaborations. It will also give an impetus to study the vast biodiversity in India.

We believe that such a course design would make the study of botany, a joyful and vibrant experience.

COURSE STRUCTURE FOR M. Sc. BOTANY PART I (SEMESTER I AND II)

Course Code	Course Name	Credits (44)
Credit Framework for Semester-I		
Major Core [10 (T) + 4 (P)]		
BOT 501 MJ	Taxonomy-I (Algae and Fungi)	2
BOT 502 MJ	Taxonomy-II (Bryophytes, Pteridophytes and Gymnosperms)	3
BOT 503 MJ	Plant Biochemistry and Physiology	3
BOT 504 MJ	Plant Genetics	2
BOT 505 MJP	Practicals based on BOT MJ501/502	2
BOT 506 MJP	Practicals based on BOT MJ503/504	2
	Total Major Core Credits	**14**
Major Elective (any one)		
BOT 510 MJ	Algal Bioprospecting	2
BOT 511 MJ	Plant Pathology	
BOT 512 MJ	Medicinal Mushroom Cultivation	
BOT 513 MJ	Post-harvest Technology	
BOT 514 MJ	Plant Breeding	
BOT 515 MJ	Industrial Botany	
BOT 516 MJ	Cultivation and Utilization of Medicinal Plants	
BOT 517 MJP	Practical Based on BOT 510 MJ	2
BOT 518 MJP	Practical Based on BOT 511 MJ	
BOT 519 MJP	Practical Based on BOT 512 MJ	
BOT 520 MJP	Practical Based on BOT 513 MJ	
BOT 521 MJP	Practical Based on BOT 514 MJ	

BOT 522 MJP	Practical Based on BOT 515 MJ	
BOT 523 MJP	Practical Based on BOT 516 MJ	
	Total Major Elective Credits	**4**
BOT 541 MN	Research Methodology	2
BOT 542 MNP	Practicals Based on BOT 541 MN	2
	Total Research Methodology Credits	**4**
	Total Credits Semester-I	**22**
Credit Framework for Semester-II		
Major Core [10 (T) + 4 (P)]		
BOT 551 MJ	Taxonomy-III (Angiosperms)	2
BOT 552 MJ	Plant Development-I	2
BOT 553 MJ	Plant Ecology	2
BOT 554 MJ	Cell Biology	2
BOT 555 MJ	Molecular Biology-I	2
BOT 556 MJP	Practicals based on BOT 551, 552 and 553 MJ	2
BOT 557 MJP	Practicals based on BOT 554 and 555 MJ	2
	Total Major Core Credits	**14**
BOT 560 MJ	Plant Tissue Culture	2
BOT 561 MJ	Plant Organism Interaction	
BOT 562 MJ	Plant Immunity	
BOT 563 MJ	Organic Farming	
BOT 564 MJ	Carbon Credit andEnvironmentImpact Assessment	
BOT 565 MJ	Millet-based Nutraceuticals	
BOT 566 MJ	Aromatic Plants	
BOT 567 MJP	Practicals based on BOT 560 MJ	2
BOT 568 MJP	Practicals based on BOT 561 MJ	
BOT 569 MJP	Practicals based on BOT 562 MJ	
BOT 570 MJP	Practicals based on BOT 563 MJ	

BOT 571 MJP	Practicals based on BOT 564 MJ	
BOT 572 MJP	Practicals based on BOT 565 MJ	
BOT 573 MJP	Practicals based on BOT 566 MJ	
	Total Major Elective Credits	**4**
BOT 581 OJT/FP	On Job Training (OJT)/Field Project (FP)	4
	Total OJT/FP Credits	**4**
	Total Credits Semester-II	**22**

SEMESTER I: CORE COURSES (Mandatory)

BOT 501 MJ Taxonomy-I (Algae and Fungi) (2 Credits: 30 Lectures)

Sr. No.	Topics Covered	Number of Lectures/ Practicals
Credit 1:Algae		**15L**
1.	Botanical nomenclature: International code of nomenclature for algae, fungi, and plants (ICN), classification system in algae	**2L**
2.	Cyanophyta: Introduction, thallus organization, cell ultrastructure, heterocyst development and function	**2L**
3.	Endosymbiosis and origin of eukaryotic algae	**1L**
4.	Chlorophyta: Structure and evolution of thallus, reproduction and life cycle with reference to orders of green algae	**3L**
5.	Charophyta: Thallus structure, reproduction and life cycle	**1L**
6.	Ochrophyta (Phaeophyceae): Thallus structure, reproduction and life cycle	**2L**
7.	Rhodophyta: Thallus structure, reproduction and life cycle	**2L**
8.	Bacillariophyta: Thallus structure, reproduction and life cycle	**1L**
9.	Euglenophyta: Thallus structure, reproduction and life cycle	**1L**
Credit 2: Fungi		**15L**
1.	Characters of fungi used for classification, system of classification by Ainsworth	**2L**
2.	Myxomycotina: Structure, Life cycle patterns of major classes	**2L**
3.	Mastigomycotina: Structure, Life cycle patterns of major classes	**2L**
4.	Zygomycotina: Structure, Thallus organization, and Evolution of sexual reproductive structures	**2L**
5.	Ascomycotina: Thallus organization, Centrum development, and Different types of ascocarps	**2L**
6.	Basidiomycotina: Tissue differentiation, Development of basidia and basidiospore	**2L**
7.	Deuteromycotina: Types of conidial ontogeny and fruiting body organization	**1L**
8.	Heterothallism, Heterokaryosis and parasexual cycle	**1L**
9.	Recent concept of origin and molecular phylogeny in fungi	**1L**

Suggested References

Algae:

1. Archibald, J. M., Simpson, A. G. B. and Slamovits, C. H. (eds.) (2017). *Handbook of the protists* (2nd ed.). Springer International Publishing AG, pp. 1657.
2. Barsanti, L. and Gualtieri, P. (2014). *Algae-anatomy, biochemistry, and biotechnology* (2nd ed.). CRC Press, Boca Raton, pp. 326.
3. Bellinger, E. G. and Sigee, D. C. (2015). *Freshwater algae: Identification, enumeration, and use as bioindicators* (2nd ed). John Wiley & Sons, Ltd., UK, pp. 275.
4. BrodieJ. and Lewis, J. (eds.) (2007). *Unravelling the algae: the past, present, and future of algal systematics(The Systematics Association Special Volume Series 75)*. CRC Press, Boca Raton, pp. 376.
5. Cole, K. M. and Sheath, R. G. (1990). *Biology of the red algae*. Cambridge University Press, USA, pp. 503.
6. Desikachary, T. V. (1959). *Cyanophyta*. ICAR, New Delhi, pp. 686.
7. Graham, L. E. and Wilcox, L. W. (2000). *Algae*. Prentice Hall, Inc., NJ, pp. 640.
8. Jha, B., Reddy, C. R. K., Thakur, M. C. and Rao, M. U. (2009). *Seaweeds of India-The diversity, and distribution of seaweeds of Gujarat coast(Development in applied phycology 3)*. Springer, Dordrecht, pp. 215.
9. Krishnamurthy, V. (2000). *Algae of India &neighbouring countries: I. Chlorophycota*. Oxford & IBH, New Delhi, pp. 222.
10. Lee, R. E. (2008). *Phycology* (4th ed.). Cambridge University Press, NY, pp. 547.
11. Misra, J. N. (1966). *Phaeophyceae in India*. ICAR, New Delhi, pp. 203.
12. Pereira, L. and Neto, J. M. (eds.) (2014). *Marine algae: Biodiversity, taxonomy, environmental assessment, and biotechnology*. CRC Press, Boca Raton, pp. 390.
13. Rai, A. N. (ed.) (2018). *Handbook of symbiotic cyanobacteria*. CRC Press, Boca Raton, pp. 253.
14. Sahoo, D. and Seckbach, J. (2015). *The algae world(Cellular origin, life in extreme habitats and astrobiology 26)*. Springer Science, Dordrecht, pp. 598.
15. Sarma, T. A. (2013). *Handbook of cyanobacteria*. CRC Press, Boca Raton, pp. 802.
16. Simpson, M. G. (2010). *Plant systematics* (2nd ed.). Elsevier Inc., NY, pp. 740.
17. Singh, P. K., Kumar, A., Singh, V. K. and Shrivastava, A. K. (eds.) (2020). *Advances in cyanobacterial biology*. Elsevier Inc., UK, pp. 403.
18. Turland, N. (2013). *The code decoded: A user's guide to the International Code of Nomenclature for algae, fungi, and plants* (Regnum Vegetabile 155). Koeltz Scientific Books, Germany, pp. 169.
19. Wehr, J. D., Sheath, R. G. and Kociolek, J. P. (eds.) (2015). *Freshwater algae of North America: Ecology and classification* (2nd ed.). Elsevier Inc., USA, pp. 1050.

Fungi:

1. Alexopoulus, C. J., Minms, C. W. and Blackwell, M. (1999). (4th Ed.) *Introductory Mycology*. Wiley, New York. Alford, R. A.
2. Deacon, J. W. (2006). *Fungal Biology* (4th Ed.) Blackwell Publishing, ISBN. 1405130660.
3. Kendrick, B. (1994). *The fifth kingdom* (paperback), North America, New York,Publisher: 3rd Ed., ISBN- 10: 1585100226.
4. Kirk et al., (2001). Dictionary of the fungi, 9th Ed., published Wallingford: CABI, ISBN: 085199377X.

5. Mehrotra, R. S. and Aneja, K.R. (1990). *An Introduction to Mycology.* New age Publishers, ISBN 8122400892.

6. Miguel U., Richard, H. and Samuel, A. (2000). Illustrated dictionary of the Mycology,Elvira Aguirre Acosta, Publisher: St. Paul, Minn: APS press, ISBN 0890542570.

7. Webster, J. and Rpland W. (2007). *Introduction to Fungi* (3rd Ed.), CambridgeUniversity Press, 978-0-521-80739-5.

BOT 502 MJ Taxonomy-II (Bryophytes, Pteridophytes and Gymnosperms)
(3 Credits: 45 Lectures)

Credit 1: Bryophytes		**15L**
1	Introduction, general characteristics, distribution, diversity and economic importance of bryophytes	**3L**
2	Classification of bryophytes	**1L**
3	Distribution, morphology, anatomy and reproductive studies, inter-relationships and evolutionary trends in the following groups- (a) Hepaticae: Sphaerocarpales,Calobryales, Takkakiales,Marchantiales, Jungermanniales (b) Anthocerotae: Anthocerotales (c) Musci: Sphagnales, Andraeales, Polytrichales, Buxbaumiales,Funariales	**4L** **1L** **5L**
4	Fossil bryophytes, recent additions of bryophytes in the Indian flora	**1L**
Credit 2: Pteridophytes		**15L**
1	Introduction, diversity,affinities with gymnosperms and importance	**2L**
2	Systems of classification	**1L**
3	Evolution: telome, steles, sori, gametophytes	**2L**
4	Origin and evolution	**2L**
5	Distribution, morphology, anatomy, reproduction andinterrelationship of following orders– Psilotales, Lycopodiales, Isoetales, Equisetales, Ophioglossales, Marratiales, Osmundales, Filicales, Marsileales, Salviniales	**7L**
6	Alternation of generations, apogamy, apospory and heterospory	**1L**
Credit 3: Gymnosperms		**15L**
1	Characters, diversity, classification systems and affinities with other groups	**2L**
2	Distinguishing featuresofProgymnosperms, Pteridospermales, Cycadeoidales, Cycadales, Caytoniales, Glossopteridales, Pentoxylales, Cordiatales and Voltziales	**2L**
3	Morphology, anatomy, sporogenesis, gametogenesis, embryology, interrelationship betweenCycadales and Ginkgoales	**2L**
4	Morphology, anatomy, reproduction and interrelationship of Pinales/Coniferales,Taxales,Gnetales, Ephedrales and Welwitschiales	**6L**
5	Seed development in Gymnosperms	**2L**
6	Economic importance and taxonomic updates	**1L**

Suggested References:

Bryophytes

1. Cavers, F. (1976). *The inter relationships of the bryophyte*. S.R. Technic, Ashok Rajpath, Patna.
2. Chopra, R. N. and Kumar, P. K. (1988). *Biology of bryophytes*. John Wiley & Sons, New York, NY.
3. Kashyap, S. R. (1929). *Liverworts of The Western Himalayas And ThePanjab Plain Part 1* Chronica Botanica New Delhi.
4. Kashyap, S. R. (1932). *Liverworts of the Western Himalayas and the Panjab plain* (illusterated): Part 2 The ChronicaBoanica New Delhi. Bryophya central Book Depot.
5. Prem puri (1981). *Bryophytes: Morphology, Growth and Differentiation*, Atmaram and Sons, New Delhi.
6. Udar, R. (1975). *Bryology in India*: Chronica Botanica Co., [c], New Delhi.
7. Udar, R. (1970). *Introduction to bryphyta*Shashidhar MalaviyaPrakashan Lucknow
8. Watson, E. V. (1971). *Structure and life of bryophytes 3rd*, Hutchinson University Library London.
9. Smith, G. M. (1955) Cryptogamic Botany Bol. II
10. Watson, E.V. (1963) : British Mosses and Liverworts
11. Watson, E.V. (1964) : The Structure and life of Bryopytes
12. Goffinet, B. (2008). *Bryophyte biology*. Cambridge University Press.
13. Shaw, A. J., &Goffinet, B. (Eds.). (2000). Bryophyte biology. Cambridge University Press.
14. Tuba, Z., Slack, N. G., & Stark, L. R. (Eds.). (2011). *Bryophyte ecology and climate change*. Cambridge University Press.

Pteridophytes

1. Rashid A. (1999) An Introduction to Pteridophyta. Vikas Publishing house Pvt.Ltd. New Delhi.
2. Sharma O.P. (1990) Textbook of Pteridophyta. Mac Millan India Ltd., Delhi.
3. Smith G.M. (1955) Cryptogamic Botany, Vol. II Mc Grew Hill **Book** Company Inc.
4. Sporne K.R. (1986) The morphology of Pteridophytes. Hutchinson University Press, London.
5. Stewart W.N. and Rothwell G.W. (2005) Paleobotany and the Evolution of plants, 2nd Edn. Cambridge University Press.
6. SundaraRajan S. (1999) Introduction to Pteridophyta. New Age International Publishers, New Delhi.
7. Parihar N.S. (1977) Biology and morphology of the Pteridophytes. Central Book Depot.

Gymnosperms

1. Agashe S.N. (1995) Paleobotany, Oxford and IBH Publ. Co.Pvt. Ltd., New Delhi.
2. AnoldA.C .(2005 Repr.) An Introduction to Paleobotany, Agrobios (India), Jodhpur.
3. Bhatnagar S.P. and Motia A. (1996) Gymnosperms. New Age International, New Delhi.
4. Biswas C. and Johri B.M. (1997) Gymnosperms. Narsa Publishing House, New Nelhi.
5. Chamberlain C.J. (1986) Structure and Evolution. CBS Publishers, New Delhi.
6. Eames E.J. (1983) Morphology of Vascular Plants. Standard University Press.
7. Johari M., Sneh Lata and Kavita Tyagi (2012) A Textbook of Gymnosperms. Dominant Publishers and Distributors, New Delhi

8. Rashid A. (1999) An Introduction to Pteridophyta. Vikas Publishing house Pvt.Ltd. New Delhi.
9. Sharma O.P. (1990) Textbook of Pteridophyta. Mac Millan India Ltd. Delhi.
10. Singh V.P. (2006) Gymnosperms (Naked seed plants): Structure and Development, Sarup and Sons, New Delhi.
11. Smith G.M. (1955) Cryptogamic Botany Vol. II Mc Grew Hill.
12. Sporne K.R. (1986) The morphology of Pteridophytes. Hutchinson University Press. London.
13. Stewart W.N. and Rothwell G.W. (2005) Paleobotany and the Evolution of plants, 2nd Edn. Cambridge University Press.
14. SundaraRajan S. (1999) Introduction to Pteridophyta. New Age International Publishers, New Delhi.
15. Surange K.R. (1966) Indian fossil Pteridophytes. Council of Scientific and Industrial research.
16. Parihar N.S. (1976) Biology and morphology of the Pteridophytes. Central Book Depot.

BOT 503 MJ Plant Biochemistry and Physiology
(3 Credits: 45 Lectures)

Credit 1: Enzymology, biomolecules and mineral nutrition		**15L**
1	Structure and properties of water, ionization of water, pH, buffers	1L
2	Bioenergetics: Free energy, changes in free energy during chemical reactions, entropy and enthalpy, high energy compounds	1L
3	Enzymology: Classification and properties of enzymes, Isoenzymes, coenzymes and cofactors, coupled reactions. Enzyme kinetics–substrate concentration and rate, competitive and non-competitive inhibitors. Covalent and allosteric regulation	3L
4	Biosynthesis and metabolism of amino acids, carbohydrates, fatty acids and lipids	3L
5	Mineral nutrition of plants: Cation-anion exchange capacity of soil, types of ion transporters, role of membrane potential in ion transport, passive and active transport, high and low affinity transporters	3L
6	Nitrogen: Uptake, assimilation and remobilization in plants, biological nitrogen fixation	2L
7	Phloem structure and function: Source and sink relationship, translocation of photoassimilates, phloem loading and unloading, composition of phloem sap	2L
Credit 2: Water uptake, photosynthesis and respiration		**15L**
1	Water uptake, transport and transpiration, stomatal physiology	2L
2	Photosynthesis: Photosynthetic pigments, organization of photosynthetic electron transport system, fluorescence and photochemistry, oxygen evolution, NADP Reduction, photophosphorylation	4L
3	Reduction of carbon dioxide: RuBPcase and Calvin cycle, photorespiration. CO_2 concentrating mechanisms in C4 and CAM plants	4L

4	Respiration: Glycolysis, citric acid cycle, pentose phosphate pathway, organization of mitochondrial electron transport system, ATP synthesis, respiratory control, anaerobic respiration	5L
Credit 3: Plant hormones and secondary metabolites		**15L**
1	Plant growth hormones: Structure, biosynthesis and metabolism of auxins, cytokinins, gibberellins, abscisic acid and ethylene, physiological role of hormones	8L
2	Photoperiodism and vernalization	3L
3	Secondary metabolite biosynthetic pathways: Terpenoids, phenolics, alkaloids	4L

Suggested References

1. Berg J.M., Tymoczko J.L., Stryrer L. (2002) Biochemistry. 5th Ed. Wlt. Freeman and Company, New York.
2. Buchanan B.B., Gruissem W., Jones R.L. (2000) Biochemistry and Molecular Biology of Plants. IK International, Mumbai.
3. Davis P. J. (Eds.) (2004) Plant Hormones. Kluwer Academic Publishers, Dordrecht, Netherlands.
4. Goodwin T.W., Mercer E.I. (1998) Introduction to Biochemistry. CBS Publishers, New Delhi.
4. Heldt H. W. (2004) Plant Biochemistry. Academic Press, California.
5. Lawlor D.W. (2001) Photosynthesis in C3 and C4 Pathway.3rd Ed. Viva. New Delhi.
6. Nelson David and Cox Michael. (2007) Lehninger Principles of Biochemistry.W.H.Freeman and Company. New York.
7. Lincoln Taiz and Eduardo Zeiger (2010) Plant Physiology, 5th edition. Sinauer Associates, Inc. Publishers. Sunder land, USA.

BOT 504 MJ Plant Genetics
(2 Credits: 30 Lectures)

Credit 1: Qualitative and quantitative genetics		**15L**
1	Mendelian principles and extensions: Co-dominance, incomplete dominance, pleiotropy, genomic imprinting, penetrance, expressivity and phenocopy, sex- linkage, sex-limited and sex-influenced characters	**3L**
2	Inheritance of complex traits: Polygenic inheritance, heritability and its measurement	**3L**
3	Karyotype analysis, evolution and applications	**2L**
4	Structural alterations of chromosomes, complex translocation heterozygotes, Robertsonian translocations and their genetic implications	**3L**
5	Population genetics: Allele frequencies and genotype frequencies, random mating and Hardy-Weinberg principle and its implications, rate of change in gene frequency through natural selection, mutation, migration and random genetic drift	**4L**
Credit 2: Microbial genetics and linkage mapping		15L
1	Mutant phenotypes, methods of genetic transfers in bacteria: transformation, conjugation and transduction, mapping of bacterial genome by interrupted mating	3L

2	Phage genetics: Phage mutants, Lytic and lysogenic cycles in phages, genetic recombination in phages, mapping bacteriophage genome, fine structure analysis of *rII*gene in T4 bacteriophage	4L
3	Linkage and mapping in eukaryotes: Linkage and crossing over, recombination, Linkage maps, LOD score for linkage testing, mapping by 3-point test cross, tetrad analysis in yeast and *Neurospora*	8L

Suggested References

1. Atherly, A.G., Girton, J.R. and Mcdonald, J. F. (1999) The science of genetics. Sauders College Pub., Fort Worth, USA.
2. Hartl, D.L., Jones E.W. (2001). Genetics: Principle and analysis (4thedn) Jones and Barlett Pub., USA.
3. Khush, G S (1973) Cytogenetics of Aneuploids. Academic press New York, London.
4. Lewin, B. Genes VIII. Oxford, University press. New York, USA.
5. Russel, P.J. 1998. Genetics (5thedn) The Benjamin/ Cummins Pub. Co., Inc. USA.
6. Snustad, D.P. and Simmons, M.J. 2000. Principles of genetics (4thedn). John Wiley and Sons, Inc., USA.
7. Cronan J., Freifelder, D. and Maloy S. R. (2008) Microbial Genetics. Narosa Publ., India
8. Strickberger, M.W: Genetics (4thedn). Mcmillan Publishing company, New York, USA.
9. Griffiths, A.J.F and Gilbert, W.M (2ndedn). Modern genetic analysis. W.H. Freeman and Company, New York, USA.

BOT 505 MJP Practicals Based on: BOT MJ 501 and BOT MJ 502
(2 Credits: 15 Practicals)

Practicals based on Algae		**3P**
1	Morphology and classification of Cyanophyta	**1P**
2	Morphology and classification of Chlorophyta	**1P**
3	Morphology and classification ofOchrophyta (Phaeophyceae) and Rhodophyta	**1P**
Practicals based on Fungi		**3P**
1	Comparative morphological and anatomical characters in Myxomycota, Zygomycotina and Mastigomycotina	**1P**
2	Comparative morphological and anatomical characters inAscomycotina, Basidiomycotina and Deuteromycotina	**1P**
3	ConstrMJion of Phylogenetic tree using MEGA software	**1P**
Practicals based on Bryophytes		**3P**
1	Taxonomic studies in Marchantiales: *Asterella, Plagiochasma, Targionia and Cyathodium*(any two)	**1P**
2	Taxonomic studies in Musci: *Sphagnum, Polytrichum, Pogonatum, Bryum*(any two)	**1P**
3	*Invivo/ in vitro* culture of Bryophytes	**1P**
Practicals based on Pteridophytes		**3P**

1	Taxonomic studies in Psilotales: *Psilotum, Tmesipteris*and Lycopodiales: *Lycopodium* (any two)	**1P**
2	Taxonomic studies in Filicales: *Anemia, Lygodium, Gleichenia, Ceratomium, Goniopteris, Phymotodes, Pteris, Acrostichum, Blechnum, Platycerum, Pteridum, Pleopeltis, Cheilanthus, Ceratopteris, Athyrium, Adiantum* (any two)	**1P**
3	Demonstration of*Azolla*cultivation	**1P**
Practicals based on Gymnosperms		**3P**
1	Taxonomic studies inCycadales and Ginkgoales	**1P**
2	Taxonomic studies in Coniferales	**1P**
3	Taxonomic studies inGnetales and Ephedrales	**1P**
BOT 506 MJP Practicals based on BOT MJ 503and BOT MJ 504 (2 Credits: 15 Practicals)		
Practicals based on BOT MJ 503 Plant Biochemistry and Plant Physiology		
1	Estimation of soluble proteins in germinating and non-germinating seeds by Lowry/Bradford method	1P
2	Estimation of total amino acids in seeds	1P
3	Estimation of ascorbic acid in ripe and unripe fruits	1P
4	Estimation of cytokinins using test system of greening of cotyledons	2P
5	Transduction of alpha-amylase activity by GA_3 in cereal grains	2P
6	Assay of nitrate reductase activity in plant tissues	2P
7	Effect of substrate concentration on K_m and V_{max} of invertase	2P
8	Effect of pH on enzyme activity	1P
9	Estimation of reducing sugars in developing fruits	2P
10	Estimation of starch in storage tissue	2P
11	Estimation of alpha-amylase activity in germinating seeds	2P
12	Estimation of invertase activity in plant tissues	2P
Practicals based on BOT 504 MJ Plant Genetics		
1	Preparation of somatic C- metaphase chromosomes and karyotype analysis in *Allium cepa*/*Aloe* sp.	2P
2	Study of meiotic configurations in *Zea mays*/*Allium cepa*, *Rhoeo* sp./*Aloe* sp., *Tradescantia s*sp. (prophase I, chiasma analysis)	2P

3	Study of chromosomal aberrations in irradiated plant material	1P
4	Study of polygenic inheritance	1P
5	Problems based on Mendelian inheritance and population genetics and linkage, estimation of gene and allele frequencies	2P
6	Tetrad analysis in *Neurospora crassa*	1P
7	Handling of *Drosophila melanogaster* for study of monohybrid, dihybrid, and sex-linked inheritance	1P
8	Study of monohybrid and dihybrid crosses and genetic interactions	1P
9	Linear differentiation of chromosomes through banding techniques: C-Banding/G-Banding/Q-Banding	2P
10	PTC testing ability/tongue rollers-non rollers in humans	1P

SEMESTER I: ELECTIVE COURSES		
Sr. No.	**Topics Covered**	**Number of Lectures/ Practicals**
BOT 510 MJ Algal Bioprospecting (2 Credits: 30 Lectures)		
Credit 1: Cultivation of Micro-and Macroalgae		**15L**
1	Isolation methods, purification and maintenance of microalgae	**2L**
2	Growth curve studies, measurement of algal growth	**2L**
3	Continuous culture system, scaling-up at laboratory and open pond system	**3L**
4	Photobioreactors and biomass production in closed system	**1L**
5	Harvesting and drying of algal biomass	**2L**
6	Economics of microalgal production	**1L**
7	Cultivation of commercially important algae: *Spirulina, Chlorella, Porphyra, Kappaphycus, Gracilaria, Laminaria*	**4L**
Credit 2: Bioprospecting of Micro-and-Macroalgae		**15L**
1	Algae as food and nutritional supplements (SCP, PUFA, etc.), animal feed	**2L**
2	Blue green algal biofertilizer,seaweed liquid fertilizer(SLF) and their applications in agriculture	**2L**

3	Algal pigments of commercial value	**1L**
4	Sources of phlorotannins and their commercial applications	**1L**
5	Biofuel (biodiesel, hydrogen and bioethanol)production from algae	**2L**
6	Algal polysaccharides: Agar, alginates, carrageenan and their commercial applications	**3L**
7	Diatomite and its commercial applications	**1L**
8	Carbon sequestration by algae	**1L**
9	Algae in waste water treatment (Phycoremediation)	**1L**
10	Intellectual property rights associated with algal bioprospecting	**1L**

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BOT 517 MJP Practicals based on BOT 510 MJ
(2 Credits: 15 Practicals)

1.	Culturing of microalgae: Isolation, purification and maintenance of algal strains	**4P**
2.	Qualitative and quantitative analysis of algal lipids	**2P**
3.	Estimation of carotenoids from commercially important algae	**1P**
4.	Extraction and purification of phycocyanin/phycoerythrin from algae	**3P**
5.	Extraction of UV protective scytonemin from cyanobacteria	**2P**
6.	Extraction of phlorotannins from algal sample	**2P**
7.	Enrichment of algal cultures for mass production	**2P**
8.	Immobilization of algae for bioprospecting	**2P**
9.	Method for production of Single Cell Protein (SCP)	**2P**
10.	Preparation of Seaweed Liquid Fertilizer (SLF)	**2P**
11.	Survey of commercially available algal products	**1P**
12.	Algal growth measurements and growth curve studies	**2P**
13.	Lyophilization of algal samples and testing for viability	**2P**
14.	Preparation of BGA biofertilizer	**2P**
15.	Extraction and purification of agar-agar and alginates	**3P**

16.	Biphasic culturing of algae from soil samples	**2P**
17.	Isolation and identification of algae from oil-spills	**2P**
18.	Visit to algal cultivation pond/institute/industry	**2P**
BOT 511 MJ Plant Pathology (2 Credits: 30 Lectures)		
Credit 1: Plant diseases and pathogens		**15L**
1.	Concept of disease, classification	**1L**
2.	Rusts, smuts, mildews, wilt, blight, rot-causing fungi, symptoms, life cycles	**5L**
3.	Leaf spot, blight, wilt scabs, cankers, soft rot caused by bacteria, mosaic and ring spot causing viruses andyellowing, stunting and wilt causing nematodes	**3L**
4.	Plant disease epidemiology: Elements of an epidemic, patterns and comparison of epidemic development and forecasting plant disease epidemics	**2L**
5.	Pathogenesis: Infection, reproduction and dissemination	**2L**
6.	Pathogen effects on plant processes and growth	**1L**
7.	Emerging pathogens and effect on sustainable agriculture	**1L**
Credit 2: Host resistance, disease management and control of diseases		**15L**
1	Plant defenses: Non-host and host resistance	**1L**
2	Pre-existing and induceddefenses: Structural and chemical	**1L**
3	Defense signaling network: Immunity, Effectors, MAPK cascadeand PRPs	**3L**
4	Pathogenicity genes: effector molecules, role of enzymes and toxins in pathogenicity	**3L**
5	Diagnostic methods for detecting pathogens	**1L**
6	Control of disease using fungicides and other chemicals	**2L**
7	Biocontrol agents for controlling disease	**2L**
8	Disease control using biological and chemical activators of resistance	**2L**

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3. Fundamentals of Plant Pathology, R S Mehrotra, Ashok Aggarwal

BOT 518 MJP Practicals based on BOT 511 MJ (2 Credits: 15 Practicals)		
1	Study of different types of diseases in commercially important crops	**4P**
2	Isolation and culture of fungal pathogen from diseased plants	**2P**
3	Counting fungal spores using haemocytometer and artificial inoculation method	**2P**
4	Study of symptoms and disease scoring for any two fungal pathogens	**2P**
5	Observation of colonization pattern using fluorescent tagged vascular pathogen	**2P**
6	Isolation of DNA from infected plant tissue and assessment of pathogen load	**3P**
7	Molecular diagnostics of plant pathogen using PCR	**3P**
8	Control of pathogens using biological agents (*Pseudomonas* sp. /PGPRs/*Trichoderma* sp./*Serendipita indica*) and plant-based formulations	**4P**
BOT 512 MJ Medicinal mushroom cultivation (2 Credits: 30 Lectures)		
Credit 1: Introduction to medicinal mushrooms		**15L**
1	Medicinal mushrooms:Introduction, importance and health benefits Global scenario of trade and demand of medicinal mushrooms	**5L**
2	Overview of active principles in medicinal mushrooms	**3L**
3	Bioactive metabolites from *Cordyceps*, solid and liquid state fermentation and quality control of *Cordycepmilitaris*	**3L**
4	Isolation, identification and utilization of mushroom metabolites	**4L**
Credit 2: Cultivation of medicinal mushrooms		
1	Cultivation of Shiitake mushroom (*Lentinusedodes*), Lion's mane (*Hericiumerinaceus*)	**2L**
2	Cultivation, nutritional value and bioactive compounds in*Morchella* and Truffles	**3L**
3	Cultivation of *Ganoderma lucidum* on different substrates and its commercial products	**5L**
4	Turkey Tail (*Trametes versicolor*) farming	**2L**
5	Development of a mushroom cultivation unit, cost-benefit analysis, institutions involved in research and development of medicin mushrooms	**3L**

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BOT 519 MJP Practicals based on BOT 512 MJ
(2 Credits: 15 Practicals)

1	Identification of commercial medicinal mushrooms	**1P**
2	Isolation and *invitro* culture of medicinal mushrooms	**1P**
3	Cultivation practice for medicinal mushrooms (*Cordycep militaris*, Morchella/Truffles/*Trametesversicolor*)	**5P**
4	Cultivation of *Ganoderma lucidum*/*Lentinus edodes*/ *Hericium erinaceus*	**5P**
5	Study of various by-products of medicinal mushrooms available in the market	**3P**
6	Analysis of nutritional compounds in medicinal mushrooms	**3P**
7	Extraction and estimation of polysaccharides and terpenoids fro medicinal mushrooms	**2P**
8	Antioxidant activity (DPPH assay) of crude metabolites from mushroom extracts	**2P**
9	Study visit to a mushroom industry/fungal research laboratory	**2P**

BOT 513 MJ Post Harvest Technology
(2 Credits: 30 Lectures)

Credit 1: Post-harvest management of crops, fruits and vegetables		**15L**
1	Importance and scope of post-harvest management of commercially important crop plants	**3L**
2	Maturity indices and harvesting techniques for commercially importa crop plants, ornamentals, fruits and vegetables	**3L**
3	Pre-harvest practices, importance and their influence on post-harve losses	**2L**
4	Post-harvest biology: ripening, fruit softening, flavor, fragrance and senescence	**2L**
5	Post-harvest treatments to prevent losses during storage, increasir shelf-life: high and low temperature, chemicals, irradiation etc.	**3L**
6	Packaging methods and transportation	**1L**
7	Storage facilities and techniques	**1L**
Credit 2: Value addition to crop, fruits and vegetables		**15L**
1	Post-harvest Processing and preservation: Cleaning, sorting, and grading o produce, drying, dehydration of plant-based food	**3L**
2	Nutritive value of fresh and processed fruits	**2L**
3	Value addition in cereals, pulses, vegetables and fruits	**3L**
4	Post-harvest practices for spices and condiments	**2L**
5	Quality and safety standards of processed food products	**3L**
6	Marketing and trade	**2L**

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BOT 520 MJP Practicals based on BOT 513 MJ
(2 Credits: 15 Practicals)

1	Effect of packaging containers on shelf life of fruits, vegetables and flowers	**2P**
2	Effect of low and high temperature on biochemical parameters determining shelf life and quality of fruits, vegetables and flowers	**4P**
3	Preparation of jam/jelly/ketchup	**2P**
4	Preparation of dried and dehydrated products	**2P**
5	Value added vegetables products	**2P**
6	Determination of pH, degree brix, nutritional parameters, TSS in fruit juice	**4P**
7	Visit to a food processing industry/institute	**2P**

BOT 514 MJ Plant Breeding (2 Credits: 30 Lectures)		
Credit 1: Principles of plant breeding		**15L**
1	Pre-and post-Mendelian concepts, plant breeding in India - major achievements and limitations, past, progress and future needs, green revolution, evergreen revolution	**2L**
2	Breeding objectives, genetic diversity in plants, centers of origin of crop plants, distribution and areas of diversity. Primary, secondary and tertiary gene pools. Importance of genetic diversity in crop improvement and its erosion	**3L**
3	Hybridization technique: Objectives, types, procedure, raising F1 generation, selfing, difficulties in hybridization	**4L**
4	Genetic basis of breeding cross pollinated crops: Genetic basis of self- incompatibility and male sterility and their use in hybrid seed production, genetic basis of inbreeding depression	**3L**
5	Crop varieties: Identification, release and notification of crop varieties, institutions involved in release of varieties	**3L**
Credit 2: Breeding Methods		
1	Breeding methods for self-pollinated crops: Mass selection, pure-line selection, pedigree selection, bulk method, backcross method	**5L**
2	Breeding methods for cross pollinated crops: Mass selection, progeny selection, recurrent selection	**5L**
3	Breeding methods for clonally propagated crops: Clonal selection, hybridization breeding for heterosis	**2L**
4	Mutations and polyploidy breeding: Mutagens: Physical and chemical mutagens, Mutant types, mutation breeding, mutant variety data (MVD)-IAEA, distant hybridization and polyploid breeding	**3L**

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BOT 521 MJP Practicals based on BOT 514 MJ Plant Breeding (2 Credits: 15 Practicals)		
1	Self and cross hybridization in selected crop species (rice, maize, mustard, etc.)	**5P**
2	Floral biology in self and cross-pollinated species, pollen viability detection	**2P**
3	Study of quality traits in rice/cotton/wheat/soybean/mustard (any three)	**3P**
4	Use of colchicine for transduction of polyploidy in appropriate plant material	**3P**
5	Demonstration of hybrid variety, heterosis, and inbreeding depression	**2P**
6	Transduction of mutations by physical/chemical mutagens and characterization of mutants	**4P**
7	Visits to plant breeding institutes within/nearby Pune	**2P**
BOT 515 MJ Industrial Botany (2 Credits: 30 Lectures)		
Credit 1: Plant-based industries		**15L**
1	Introduction, various plant resources, demand and supply	**2L**
2	Paper industry: Plant resources, pulp, paper manufacturing	**1L**
3	Plant fiber industry: Sources, commercial fibers, floss, cultivation, processing and utilization	**2L**
4	Rubber industry: Plant sources, cultivation, processing and utilization	**1L**
5	Natural dyes: Sources, cultivation, processing and utilization	**1L**
6	Gums and resins: Sources, cultivation, processing and utilization	**1L**
7	Timber industry: Commercial sources, silvicultural techniques, utilization	**1L**
8	Wood-based industry: Sources for musical instruments, toys, pencils, sports goods, etc., manufacturing methods and utilization	**2L**
9	Bamboo industry: Diversity, cultivation, harvesting, utilization and value addition	**2L**
10	Rattan: Sources, manufacturing of different products and uses	**1L**
11	Tannin industry: Commercial sources, manufacturing and utilization	**1L**
Credit 2: Commercial botany		**15L**
1	Edible oils: Sources, cultivation, processing and utilization	**2L**

2	Tree-borne oil-seeds (TBOs): Wild sources, Good Field Collection Practices (GFCPs), processing, value addition and uses	**2L**
3	Aromatic oils: Sources, commercially important oils, cultivation, processing and utilization	**2L**
4	Nutraceuticals and food supplements: Wild fruits and vegetables, tubers, millets: sources and commercial utilization	**2L**
5	Herbal medicine: Commercially important herbs, utilization and processing, industrial applications	**2L**
6	Botanical pesticides: Sources, processing and value addition	**1L**
7	Landscape gardening: Plant resources, availability, propagation and cultivation	**1L**
8	Exotic fruits: Sources, cultivation, processing and utilization	**1L**
9	Spices and condiments: Bioprospecting and cultivation	**1L**
10	Plant-based tourism: Agro, Eco, Health, Forest, etc.	**1L**

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BOT 522 MJP Practicals based on BOT 515 MJ Industrial Botany
(2 Credits: 15 Practicals)

1	Identification and characterization of industrially important medicinal plants	**2P**
2	Pulp preparation technique for paper industry	**1P**
3	Identification of fibre-yielding plants and extraction of fibres	**2P**

4	Identification of dye-yielding plants and their extraction methods	**2P**
5	Types of gums and resins, extraction and storage methods	**1P**
6	Bamboo propagation and cultivation	**2P**
7	Pharmacognostic studies of locally available medicinal plants in trade	**2P**
8	Distillation of essential oils from commercial aromatic plants	**2P**
9	Primary processing, packaging techniques and marketing of medicinal plants	**2P**
10	Identification of spices and condiments, their processing and storage techniques	**2P**
11	Establishment of concept garden by landscape technique	**4P**
12	Identification of plant sources as food supplements and nutraceuticals	**1P**
13	Methods for extraction of tannins	**1P**
14	Identification of woods and manufacturing of wood articles	**2P**
15	Preparation method for plant-based pesticide and testing	**2P**
16	Project proposal writing for financial assistance to establish plant-based unit for submission to bank/various organizations/NGOs, etc.	**2P**
17	Demonstration of accounting and marketing of plant-based products	**2P**
18	Industrial visit for demonstration of equipment, instruments and infrastructure required for plant-based industry	**2P**
BOT 516 MJ Cultivation and Utilization of Medicinal Plants (2 Credits: 30 Lectures)		
Credit 1: Cultivation and conservation		**15L**
1	Medicinal plants: aspects and prospects	**1L**
2	Medicinal plants used in various systems of traditional medicines, medicinal plants in demand, supply and sources	**3L**
3	Good Agricultural Practices (GAPs) of selected commercially important medicinal plants	**6L**
4	Good Field and Collection Practices (GFCP), primary processing	**2L**
5	Conservation and utilization of medicinal plant resources	**2L**
6	Markets in India, major traders, processers/pharma associations	**1L**
Credit 2: Start-up requirements		**15L**
1	Value addition: processing and product development (oils, powder, granules, herbal tea, nutraceuticals, cosmeceuticals, cosmetics, medicated water, tablets, health drinks, *Chyavanprash*, candy, etc.), innovative products	**4L**

2	Requirement for start-ups: infrastructure, machinery, manpower, testing laboratory, legal permissions	**2L**
3	Rules and regulations: GOI Ministries, FDA, FSSAI, Pollution Control Board, etc.	**2L**
4	Government Schemes and organizations involved in promotion of medicinal plants, Skill India Program, campaigns on medicinal plants, Ayush and MSME ministry	**2L**
5	Organic certification: Procedure and documentation	**2L**
6	Quality control: Various norms and tests	**2L**
7	Intellectual property right (IPR) issues	**2L**

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BOT 523 MJP Practicals based on BOT 516 MJ Cultivation and Utilization of Medicinal Plants		
1	Identification of major medicinal plants	**2P**
2	Identification of fresh and dried raw materials of medicinal plants in trade	**3P**
3	Nursery techniques for production of QPMs of medicinal plants, seed production	**2P**
4	GAPs for medicinal plants: Ashwagandha, Senna, Pippali	**3P**
5	Preparation of value-added products from amla, giloy, adulsa	**3P**
6	Post-harvest techniques for medicinal plants, processing and packaging: drying, grading, sorting and storage	**3P**
7	Extraction and identification of phytochemicals by Thin Layer Chromatography (TLC)	**2P**

BOT 541 MN Research Methodology (2 Credits: 30 Lectures)		
Credit 1: Foundation of research and execution		**15L**
1	Types of research, characteristics of scientific methods, understandin the language of research - concept, construct, definition, variables	**3L**
2	Importance of literature survey, sources of information, assessment of quality of journals and articles, effective literature studies approaches	**3L**

3	Formulation of research questions and hypothesis, hypothesis testing design of experiments	**3L**
4	Data analysis and application of statistical methods: sampling, data collection and documentation; analysis of qualitative and quantitative data- univariate, bivariate, and multivariate analysis. Outliers in the data. Statistical software	**5L**
Credit 2: Research ethics, safety measures, writing, and presentation skills		**15L**
1	Acts and biodiversity laws, permissions for plant collection, authentication of plant specimens, ethical issues, ethical and biosafet committees. Safely levels and permissions, plagiarism and self-plagiarisr Intellectual property rights- patent, designs, trade and copyright, ar patent law	**4L**
2	Lab safety measures: handling of chemicals, radioactive materials, instruments, disposals of chemicals and biological waste	**2L**
3	Dissertation: Different steps in the preparation - Layout, structure ar language of typical reports. Illustrations and tables, bibliograph footnotes, and acknowledgement. Preparation of effective presentatic	**6L**
4	Software for paper formatting, grammar checking, referencing, ar plagiarism detection	**3L**

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3. A Manual for Writers of Research Papers, Theses, and Dissertations, Ninth Edition. Chicago Style for Students and Researchers. Kate L. Turabian, Gregory G. Colomb, Joseph Bizup, Joseph M. Williams, Wayne C. Booth, William T. FitzGerald. University of Chicago Press.
4. A Professor's Guide to Writing Essays. The No-nonsense Plan for Better Writing. Second edition. Jacob Neumann.
5. Cite Right, Third Edition: A Quick Guide to Citation Styles--MLA, APA, Chicago, the Sciences, Professions, and More (Chicago Guides to Writing, Editing, and Publishing). Charles Lipson. University of Chicago Press.
6. Handbook of Biological Statistics (3rd ed.). McDonald, J.H. Sparky House Publishing, Maryland.

BOT 542 MNP Practicals based on BOT 541 MN Research Methodology (2 Credits: 15 Practicals)

1	Formulation of hypothesis and its testing	**2P**

2	Analysis of qualitative and quantitative data sets	**3P**
3	Handling Systat/PAST3 for statistical analysis	**3P**
4	Making tables and graphs using Microsoft Excel	**3P**
5	Handling of Mendeley for referencing	**2P**
6	Manuscript formatting using Microsoft word	**2P**
7	Review writing, various databases	**3P**
8	Handling of Microsoft power point for scientific presentation	**2P**

SEMESTER II: CORE COURSES (Mandatory)		
BOT 551 MJ Taxonomy-III (Angiosperms) (2 Credits: 30 Lectures)		
Credit 1: Fundamentals of taxonomy		**15L**
1	Origin of angiosperms, cradle of angiosperms, abominable mystery, fossil angiosperms	**2L**
2	Morphological features used in identification of angiosperms	**3L**
3	Taxonomy: definition, aims, principles and importance. Taxonomic tools and literature: Flora, monograph, revisions, herbarium, botanic gardens, journals, websites. Organizations involved in angiosperm taxonomy	**2L**
4	Floristics: need and significance,history, methods, botanical explorations inIndia	**1L**
5	Global Taxonomy Initiatives:systematics agenda- 2000, systematics knowledge and value of biodiversity,biodiversity strategy and systematics agenda for 2020	**3L**
6	Systems of classification:brief history, artificial systems: Carl Linnaeus, Natural system: Bentham & Hooker Phylogenetic systems: Engler &Prantl, Cronquist, Takhtajan,	**4L**
Credit 2: Advances in taxonomy		
1	Overview of APG system of classification	**2L**
2	Families of angiosperms: Characteristic features, interrelationships and economic importance of following clades: ANA Grade: Nymphaeaceae Magnoliids: Magnoliaceae Monocots: Acorales-Poales Eudicots: Ranunculaceae and Core Eudicots: Amaranthaceae Superrosids: Crassulaceae Rosids-I: Fabaceae (Leguminosae) Rosids-II: Malvaceaeand Superasterids: Santalaceae Euasterids-I: Lamiaceae and Euasterids-II: Asteraceae	**1L** **1L** **3L** **1L** **1L** **1L** **1L** **1L**
3	Endemism, hotspots, IUCN categories	**3L**
Suggested References		

1. Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181: 1–20.
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BOT 552 MJ Plant Development-I
(2 Credits: 30 Lectures)

Credit 1: Basic Concepts in Plant Development		**15L**
1	Basic processes in plant development a. Competence, determination, commitment, specification, induction, differentiation, dedifferentiation and redifferentiation b. Morphogenetic gradients, cell fate and cell lineages c. Polarity and symmetry d. Juvenility and transition to adult phase	**4L**
2	Development of epidermal structures: trichomes and stomata	**2L**
3	Development of vascular elements: differentiation of xylem and phloem	**2L**
4	Secondary growth: cambium, gross structure of wood	**2L**
5	Development of secretory tissues: nectaries, laticifers and resin ducts	**2L**
6	Transition from vegetative to reproductive phase: induction, morphological and biochemical changes in shoot apex and floral meristems	**3L**
Credit 2: Vegetative Development		**15L**
1	Meristem types and activities of meristems. Organization of shoot ar root apical meristems. Regulation of meristem size, lateral organ initiation from root and shoot meristems	**3L**
2	Leaf development, plastochron and phyllotaxy	**2L**
3	Molecular genetics of rootdevelopment Molecular genetics of shoot development Molecular genetics of leaf development	**3L** **4L** **3L**

Suggested References

1. The Arabidopsis Book. (www.arabidopsisbook.org)
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18. Wolpert L., Tickle C. and Arias A. M. (2015) Principles of Development. (5th Edition) Oxford University Press.

BOT 553 MJ Plant Ecology
(2 Credits: 30 Lectures)

Credit 1: Population Ecology		**15L**
1	Concept and scope of Ecology	**1L**
2	Autecology,SynecologyandMacroecology	**1L**
3	Ecological Models:Concepts, classification, model building and tools	**1L**
4	Molecular Ecology: Concept, tools,applications	**2L**
5	Population Ecology: Characteristics of population	**1L**
6	Ecological limits and size of the population	**2L**
7	Life history strategies and evolution, CSR triangle	**2L**
8	Metapopulation: Concept, types and dynamics, theory of island biogeography	**3L**
9	Extinction events, population viability analysis	**2L**
Credit 2: Community Ecology		**15L**
1	Concept, niche, ecotone and edge effect, evolution and coevolution	**3L**
2	Plant-plant interactions:types, epiphytic, parasitism and allelopathy	**3L**
3	Intra- and inter-specific interactions: competition, predation, herbivory	**2L**
4	Community structure, genetic and species diversity	**2L**
5	Qualitative and quantitative analysis of community	**2L**
6	Physiognomy and phenology of community	**1L**

7	Plant community in changing environment:disturbance, climate change and invasion	**2L**

Suggested References

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2. Odum, E. P. (2007) *Fundamentals of Ecology*, 5th edition, Thomson books.
3. Coleman, D.C., Crossley, D. A. and Handrix, P. F (2004) *Fundamentals of Soil Ecology*, 2ndedition, Elsevier academic press.
4. Ambhast, R. S. (1998) *A Text Book of Plant Ecology*, 9th edition, Friend and Co.
5. Canter L (1996) *Environmental Impact Assessment*, 2nd Edition, McGraw Hill Publishing Company.
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9. Mittelbach, G. G., & McGill, B. J. (2019). *Community Ecology*. Oxford University Press.
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17. Dighton, J. (2018). *Fungi in Ecosystem Processes*. CRC Press
18. Cronk, J. K. and Siobhan Fennessy, M. (2001). *Wetland Plants*. CRC Press
19. Lemon, E. R. (2019). *CO2 and Plants*. The Response of Plants to Rising Levels of Atmospheric Carbon Dioxide. CRC Press
20. Davet, P. (2004). Microbial Ecology of Soil and Plant Growth. CRC Press
21. Schulze, E.D., Beck, E. and Muller-Hohenstein, K. (2002). Plant Ecology. Springer

BOT 554 MJ Cell Biology
(2 Credits: 30 Lectures)

Credit 1: Cell organelles, cell cycle and senescence		**15L**
1	Cell wall: Biogenesis, ultra-structure, primary and secondary wall, cell expansion and elongation, functions	**2L**
2	Cell membranes:molecular organization, transport of ions across membranes, membrane transport proteins, structure and role of plasmodesmata	**2L**

3	Cell organelles: structure and function of vacuole, ER, mitochondria, chloroplast, Golgi complex, nucleus	**4L**
4	Cell cycle:phases of cell cycle, functional importance, check points, molecular events and regulation of cell cycle	**3L**
5	Senescence, programmed cell death, apoptosis, receptors and other proteins involved in selective autophagy, intracellular homeostasis	**4L**
Credit 2: Signal transduction		
1	Signal transduction: Types of receptors, G-proteins and G-protein coupled receptors	**4L**
2	Phospholipid signaling, Ca^{2+} calmodulin cascade, diversity in protein kinases and phosphatases, secondary messengers, regulation of signaling pathways	**6L**
3	Specific signaling mechanisms: biotic and abiotic stress, ABA induced stomatal closure	**3L**
4	Nuclear: organelle signaling during plastid development	**2L**
BOT 555 MJ Molecular Biology-1 (2 Credits: 30 Lectures)		
Credit 1: DNA and RNA		**15L**
1	DNA structure: types of base pairing, unusual structures, topology	**2L**
2	Melting and reassociation of DNA, Cot curves and kinetic complexity of DNA. Organization of genomes, repetitive and unique sequences, C value paradox, number of genes, rot curves and gene expression, gene duplication and divergence	**3L**
3	Packaging of genomes in nuclei, structure of chromatin, nucleosome positioning,histone modifications,chromosome organization, centromeres, telomeres	**3L**
4	Initiation, elongation and termination of DNA replication, molecular machinery of DNA replication in prokaryotes and eukaryotes	**3L**
5	RNA structure: modified bases, pairing, secondary structure	**1L**
6	Transcription units, RNA polymerases, initiation, elongation and termination of transcription in prokaryotes and eukaryotes	**3L**
Credit 2: Protein synthesis and translocation		**15L**
1	Protein synthesis: tRNA charging, ribosomal organization. Initiation, elongation and termination of protein synthesis in prokaryotes and eukaryotes,proof reading	**5L**
2	Post-translational processing of proteins, protein modifications. Chaperones and protein folding	**3L**
3	Proteases,ubiquitination and degradation of proteins by proteasomes	**2L**
4	Protein targeting in cell organelles and secretory proteins	**3L**

5	Seed-storage proteins in cereals and legumes	**2L**

Reference books

1. Genes IX– Benjamin Lewin, Jones and Bartlett, 2008
2. Genes X– Benjamin Lewin, Jones and Bartlett, 2011
3. Molecular Biology of the Cell – Alberts, B, Bray, D, Raff, M, Roberts, K and Watson JD, Garland Publishers, 1999
4. Principles of Biochemistry – Lehninger, W.H. Freeman and Company, 2005

BOT 556 MJP Practicals on BOT 551, 552, 553 MJ		
Practicals based on BOT MJ 551 Taxonomy III (Angiosperms)		
1	Identification and study of plant species using taxonomic tools	**2P**
2	Preparation of herbarium specimens, documentation and digitization (physical vs. virtual)	**2P**
3	Studies on the following Classes as per Bentham and Hooker's system of classification at least one family from each group/class/order and preparation of artificial keys for identification of any two unknown specimen: **Dicotyledons:** a. Polypetalae:Thalamiflorae, Disciflorae, Calyciflorae b. Gamopetalae:Inferae, Heteromerae, Bicarpellatae c. Monochlamydae:Curvembryae, Multiovulateaquaticae, Multiovulateterrestris, Microembryae, Daphniales, Achlamydosporae, Unisexuales, *Ordines anomali*. **Monocotyledones:** a. Microspermae b. Epigynae c. Coronariae d. Calycinae e. Nudiflorae f.Apocarrae g. Glumaceae	**7P** **4P**
4	Identification of economically important plants	**3P**
5	Ex-situ conservation methods of biodiversity – through seed, vegetative methods. (any one plant species per technique)	**2P**
Practicals based on BOT MJ 552 Plant Development-I		**5P**
1	Isolation of vegetative and reproductive apical meristems and their comparison	**1P**
2	Comparative studies on stomatal types in dicots and monocots	**1P**
3	Observation of epidermal (trichomes, glands and lenticels) and secretory (nectaries and laticifers) structures	**1P**
4	Histochemical comparison of vegetative and reproductive shoot apex	**2P**

Practicals based on BOT MJ 553 Plant Ecology		
1	Determination of minimum size of sampling unit for studying specific plant community	**2P**
2	Determining frequency, density, abundance and Importance Value Index (IVI) of the species in a plant community	**3P**
3	Calculating species richness, similarity, diversity indices, cluster analysis and coordination in different plant communities	**2P**
4	Analyses and interpretation of plant population data	**1P**
5	Effect of leaf leachates on seed germination/saplings	**2P**
6	Isolation and observation of root-associated microbes	**2P**
7	Study of stratification and physiognomy of a plant community	**1P**
8	Determination of similarity and association index	**1P**
BOT MJP 557 Practicals based on BOT 554 and 555 MJ		
Practicals based on BOT MJ 604 Cell Biology		
1	Isolation of chloroplast fraction for: a. Studying Hill reaction b. Measuring size and number of broken and intact chloroplast	2P
2	Cytochemical studies of special cell types: guard cells, senescent cells, bundle sheath cells, meristematic cells, laticiferous cells, glandular cells	**3P**
3	To induce and study senescence in leaf samples	**2P**
4	To induce plasmolysis and observe plasmodesmatal connections in plant cells	**1P**
Practicals based on BOT MJ 605 Molecular Biology		**5P**
1	Isolation and quantification of plasmid DNA	**2P**
2	Electrophoretic separation of plasmid isoforms	**1P**
3	Isolation and quantification of plant genomic DNA	**2P**
4	Effect of temperature and alkali on absorbance of DNA	**1P**
5	Isolation of seed-storage proteins from leguminous seeds and quantitation of each fraction	**2P**
6	SDS-PAGE-based separation of globulins and relative molecular weight determination	**3P**

SEMESTER II: ELECTIVE COURSES		
BOT 560 MJ Plant Tissue Culture (2 Credits: 30 Lectures)		
Credit 1: Fundamentals of plant tissue culture (PTC)		**15L**
1	History and conceptsunderlying PTC	**2L**
2	Laboratory set up: Sterility, Growth media, Nutrients and Plant Growth Regulators	**2L**
3	Micropropagation: selection of explants, media, growth regulators, stages and case studies	**5L**
4	Callus and cell suspension cultures: selection of explants, media, growth regulators, growth kinetics, bioreactors and case studies	**6L**
Credit 2: Applied aspects of PTC		**15L**
1	Somaclonal variation, androgenesis, germplasm conservation and cryopreservation	**5L**
2	Somatic embryogenesis and synthetic seed production	**2L**
3	Protoplast isolation and culture,somatic hybridization	**2L**
4	Plant production: scaling up, cost and budget-related aspects	**3L**
5	Export potential of PTC-based products and quality control	**3L**

Suggested References

1. Bajaj Y. P. S. Ed. (1988) Biotechnology in Agriculture and Forestry – vol. 4, Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.
2. Chandra S., Lata H. and Varma A. (2013) Biotechnology for Medicinal Plants. Micropropagation and Improvement. Springer-Verlag, Berlin, Heidelberg.
3. Charlwood B. V. and Rhodes M. V. Ed. (1999) Secondary products from plant tissue culture. Clarendon Press, Oxford.
4. Cseke L. J., Kirakosyan A., Kaufman P. B., Warber S., Duke J. A. and Brielman H. L. (2006) Natural Products from Plants. 2nd Edition, CRC Press, Taylor & Francis Group.
5. Das H. K. Ed. (2007) Textbook of Biotechnology. 3rd Edition. Wiley India (P) Ltd.
6. Fu T.-J., Singh G. and Curtis W. R. (2000) Plant Cell and Tissue Culture for the Production of Food Ingredients. Springer International Edition. Springer (India) Pvt. Ltd., New Delhi.

7. Jain S. M. and Saxena P. K. (2009) Protocols for in vitro Cultures and Secondary Metabolite Analysis of Aromatic and Medicinal Plants. Humana Press.
8. Kurz W.G.W. Ed. (1989) Primary and Secondary Metabolism of Plant and Cell Cultures, Springer Verlag, Berlin.
9. Morris, A.H. et al., Eds (1986) Secondary Metabolism in Plant Cell Cultures, Cambridge Univ. Press, Cambridge, U.K.
10. Trigiano R. N. and Gray D. J. (1999) Plant Tissue Culture Concepts and Laboratory Exercises. 2nd Edition. CRC Press, Boca Raton, New York.
11. Verpoorte R. and Alferman H. W. (Editors) (2003) Metabolic engineering of plant secondary metabolites. Kluwar Academic Publishing.

BOT 567 MJP Practicals Based on BOT 560 MJ Plant Tissue Culture (2 Credits: 15 Practicals)		
1	Preparation of nutrient media, sterilization of glassware and media, maintenance of aseptic conditions	**2P**
2	Micropropagation of *Withania* sp./Gerbera/*Gladiolus*/Carnation: explant selection, surface sterilization, media preparation, inoculation, incubation and sub-culturing	**5P**
3	Callus culture of sugar beet: explant selection, surface sterilization, media preparation, inoculation, incubation and sub-culturing	**4P**
4	Extraction and separation of pigments from beet root callus	**3P**
5	Standardization of a low cost micropropagation protocol	**4P**

BOT 561 MJ Plant-Organism Interaction (2 Credits: 30 Lectures)		
Credit 1: Plants interacting with macro-organisms		**15L**
1	Beneficial interaction: Plant-pollinator interaction, pollination mutualism (obligate and facultative). Interrelationship between floral morphology, chemistry and pollination	**3L**
2	Different insect herbivores and their feeding patterns, plant defense strategies, growth-defense trade-offs. Plant-mollusks interaction	**4L**
3	Plant defense mechanisms against herbivores: defense signaling, defense moleculesand cross-talk,tritrophic interactions	**5L**
4	Below ground interaction: Plant-nematode interaction- recognition, signaling, mechanism, defense molecules against nematodes	**3L**

Credit 2: Plants interacting with micro-organisms		**15L**
1	Lichens: types, symbiotic partners, relationship and mutualism	**2L**
2	Endophytes: types, association, role in plant growth promotion and alleviation of biotic and abiotic stress	**4L**
3	Mycorrhizal symbiosis: ecto- and endo mycorrhizae, mycorrhizal induced resistance, role in plant growth promotion and alleviation of biotic and abiotic stress, tritrophic interactions	**5L**
4	Nodulating bacteria: *Rhizobium*, nod factors, mechanism of nitrogen fixation	**1L**
5	Nematophagous fungi: diversity, physical and biochemical interactions between nematodes and fungi, biological control	**3L**

Suggested References

1. Hormonal Cross-Talk, Plant Defense and Development. Plant Biology, Sustainability and Climate Change **(**2023)- Edited by: AzamalHusen and Wenying Zhang.
2. Plant-Microbe Interaction - Recent Advances in Molecular and Biochemical Approaches (2023) Volume 2: Agricultural Aspects of Microbiome Leading to Plant Defence.Edited by: Prashant Swapnil, Mukesh Meena, ... Andleeb Zehra.
3. Variable Plants and Herbivores in Natural and Managed Systems (1983) Edited by: Robert F. Denno and Mark S. McClure
4. Herbivores: Their Interactions with Secondary Plant Metabolites **(**1991**)** Volume I: The Chemical Participants**.** Second Edition**.** Edited by: Gerald A. Rosenthal and May R. Berenbaum.
5. Herbivores: Their Interactions with Secondary Plant Metabolites (1992). Volume II: Ecological and Evolutionary Processes. Second Edition. Edited by: Gerald A. Rosenthal and May R. Berenbaum.
6. Fungal endophytes in plants (2018). Edited by Gary A. Strobel.
7. Microbial endophytes (2020) Functional Biology and Applications. eBook ISBN:9780128226650. Edited by: Ajay Kumar. Radhakrishnan A.K.
8. Mycorrhizal Symbiosis (2008). 3rd edition. Sally Smith and David Read. eBook ISBN:9780080559346.
9. Arbuscular Mycorrhizae Interactions in Plants, Rhizosphere, and Soils (2002). Edited By: AK Sharma and BN Johri
10. Molecular Mycorrhizal Symbiosis (2016). Online ISBN: 9781118951446 |DOI:10.1002/9781118951446. Edited by: Francis Martin

BOT 568 MJP Practicals based on BOT 561 MJ Plant-Organism Interaction (2 Credits: 15 Practicals)		
1	Study of different feeding guilds	**1P**
2	Effect of herbivory on plant photosynthesis and growth	**2P**
3	Estimation of levels of plant defense molecules before and after herbivory	**3P**
4	Effect of host and non-host plants on herbivore performances	**3P**
5	Estimation of flavonoids in nematode infested plants	**2P**
6	Effect of plant defense metabolites on insect growth	**3P**
7	Estimation of green leaf volatiles (GLVs) upon herbivory by GCMS	**3P**
8	Isolation of Arbuscular Mycorrhizal Fungi (AMF) from rhizosphere and determination of percent colonization in plant roots	**2P**
9	*In vivo* culture, maintenance of AMF and its effect on plant growth	**3P**
10	Observation and documentation of various lichen forms in nearby forest area	**2P**
11	Isolation, *in vitro* culture and testing of nitrogen fixing ability of nodulating and non-nodulating bacteria	**2P**
12	Isolation and observation of nematodes from rhizospheric soil/root galls	**2P**
BOT 562 MJ Plant Immunity (2 Credits: 30 Lectures)		
Credit 1: Pathogen perception, defense signaling and resistance		**15L**
1	Overview of host pathogen interaction, plant pathogens, pests and plant diseases	**2L**

2	Host and non-host defenses: Pre-existing and induced structural and chemical defenses	**2L**
3	Active defense: pathogen recognition (PAMPs and DAMPs), plant receptors (PRRs and NLRs), PTI, ETI, resistosomes	**3L**
4	Signal transduction pathways activated during plant resistance to pathogens, role of MAPK signalling, role of SA and JA signalling	**4L**
5	Transcriptional reprogramming in plant defense and role of transcription factors	**3L**
6	Role of pathogenesis related proteins (PRPs) and specialized secondary metabolites in defense	**2L**
Credit 2: Priming, induced resistance and small RNAs		**15L**
1	Concept of priming, induced resistance: SAR and ISR, chemical induced resistance	**4L**
2	Phytohormone cross talk in SAR and ISR	**2L**
3	Epigenetic control of plant defense mechanism	**2L**
4	Cross kingdom role of small RNAs in interaction, HIGH and SIGS	**4L**
5	Genetic engineering forplant disease resistance	**3L**

Suggested References

1. Agrios Plant Pathology, 6th Edition, Editor Richard Oliver

2. Plant Pathology and Plant Pathogens, John A. Lucas, WILEY

3. Biochemistry and Molecular Biology of Plants, 2nd Edition,Bob B. Buchanan (Editor), Wilhelm Gruissem (Editor), Russell L. Jones (Editor), WILEY

BOT 569 MJP Practicals based on BOT 562 MJ Plant Immunity		
1	Culture and maintenance of fungal pathogens	**2P**
2	Artificial inoculation of fungal pathogen and disease scoring	**3P**
3	Detection of H_2O_2 accumulation in infected plant tissue by DAB staining	**1P**

4	Detection of callose deposition in infected plant tissue	**1P**
5	Time course evaluation of antioxidative enzyme activity during fungal infection	**3P**
6	Expression analyses of defense genes in infected plant tissue	**4P**
BOT 563 MJ Organic Farming (2 Credits: 30 Lectures)		
Credit 1: Fundamentals of organic farming		**15L**
1	Historical overview: Importance, principles and advantages of organic farming	**2L**
2	Organic farming practices: Crop rotation, diversification, composting, vermicomposting, green manuring, biofertilizers, microbial consortia, IPM,IKS in organic farming, biodynamic farming, permaculture, community supported agriculture, biomass utilization	**5L**
3	Organic farming for specific crops: Cereals, pulses, millets, vegetables, spices, fruits, medicinal and aromatic plants	**5L**
4	Plant resources required forbee keeping (apiculture) and sericulture	**2L**
Credit 2: Marketing and certification, Government policies15L		
1	Social aspects of organic farming, organic farming certification process, organic market trends in India, marketing organic produces, organizations and associations involved	**5L**
2	Government policies,national programmes and support for organic farming in India, incentives and subsidies, government schemes	**5L**
3	Challenges and future of organic farming, solutions and innovations, future prospects and opportunities, success stories/case studies, organic producer companies/ farmers/ NGOs	**5L**

Suggested References

1. Awasthi, L. P. (Ed.). (2021). Biopesticides in organic farming: recent advances.
2. Barbieri, P., Starck, T., Voisin, A. S., &Nesme, T. (2023). Biological nitrogen fixation of legumes crops under organic farming as driven by cropping management: A review. *Agricultural Systems*, *205*, 103579.

3. Biswas, S., Ali, M. N., Goswami, R., & Chakraborty, S. (2014). Soil health sustainability and organic farming: A review. *Journal of Food Agriculture and Environment*, *12*(3-4), 237-243.
4. Chandrashekar, H. M. (2010). Changing scenario of organic farming in India: An overview.
5. Das, S., Chatterjee, A., & Pal, T. K. (2020). Organic farming in India: a vision towards a healthy nation. *Food Quality and Safety*, *4*(2), 69-76.
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7. Dhiman, V. (2020). Organic farming for sustainable environment: Review of existed policies and suggestions for improvement. *International Journal of Research and Review*, *7*(2), 22-31.
8. Joachim, S. (2006). Review of history and recent development of organic farming worldwide. *Agricultural sciences in China*, *5*(3), 169-178.
9. Lakner, S., &Breustedt, G. (2017). Efficiency analysis of organic farming systems a review of concepts, topics, results and conclusions. *German Journal of Agricultural Economics*, *66*(2), 85-108.
10. Lammerts van Bueren, E. T., Jones, S. S., Tamm, L., Murphy, K. M., Myers, J. R., Leifert, C., & Messmer, M. M. (2011). The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: A review. *NJAS: Wageningen Journal of Life Sciences*, *58*(3-4), 193-205.
11. Lund, V., &Algers, B. (2003). Research on animal health and welfare in organic farming—a literature review. *Livestock Production Science*, *80*(1-2), 55-68.
12. Lynch, D. H., MacRae, R., & Martin, R. C. (2011). The carbon and global warming potential impacts of organic farming: does it have a significant role in an energy constrained world?. *Sustainability*, *3*(2), 322-362.
13. Mukherjee, K., Konar, A., & Ghosh, P. (2022). Organic farming in India: A brief review. *International Journal of Research in Agronomy*, *5*(2), 113-118.
14. Reddy, B. S. (2010). Organic farming: status, issues and prospects–a review. *Agricultural Economics Research Review*, *23*(347-2016-16927), 343-358.
15. Röös, E., Mie, A., Wivstad, M., Salomon, E., Johansson, B., Gunnarsson, S., ... & Watson, C. A. (2018). Risks and opportunities of increasing yields in organic farming. A review. *Agronomy for sustainable development*, *38*, 1-21.
16. Sani, M. N. H., & Yong, J. W. (2021). Harnessing synergistic biostimulatory processes: A plausible approach for enhanced crop growth and resilience in organic farming. *Biology*, *11*(1), 41.
17. Sapbamrer, R., &Thammachai, A. (2021). A systematic review of factors influencing farmers' adoption of organic farming. *Sustainability*, *13*(7), 3842.
18. Singh, R., Jat, N. K., Ravisankar, N., Kumar, S., Ram, T., & Yadav, R. S. (2019). Present Status and Future Prospects of Organic Farming in India. *Sustainable Agriculture*, *275*.
19. Soni, R., & Sharma, A. (2016). Vermiculture technology: a novel approach in organic farming. *Indian Horticulture Journal*, *6*(1), 150-154.
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21. Yadav, S. K., Babu, S., Yadav, M. K., Singh, K., Yadav, G. S., & Pal, S. (2013). A review of organic farming for sustainable agriculture in Northern India. *International Journal of Agronomy*, *2013*.

BOT 570 MJP Practicals based on BOT 563 MJ Organic Farming (2 Credits: 15 Practicals)		
1	Designing and planning of organic farm and maintenance of field record	**1P**
2	Preparation of vermicompost/green manure/organic manure and analyses of N, P, K	**2P**
3	Preparation of bacterial biofertilizer and testing its *in vitro* plant growth promoting activity	**3P**
4	Identification of pests and diseases and their biocontrol using biopesticides	**2P**
5	Preparation of *Panchgavya*, *Beejamrut* and *Jeevamrut*and its effect on plant growth promotion	**2P**
6	Physico-chemical analyses of soil	**2P**
7	Procedure for documentation and certification of organic products	**1P**
8	Visit to a biofertilizer manufacturing unit, organic farm and market	**2P**

BOT 564 MJ Carbon Credit and Environment Impact Assessment (2 Credits: 30 Lectures)		
Credit 1: Carbon and green credit		**15L**
1	Concept and significance, green credit importance, greenhouse gases, global warming andnet zero concept	**2L**
2	Carbon credit initiative, Paris climate agreement, Glasgow COP26 climate change summit	**2L**
3	Carbon trading credit and carbon market,status in developed and developing countries	**2L**
4	Carbon trading emissions under Kyoto protocol, CDM, emission trading in India	**2L**
5	Plants and mitigation of pollution	**1L**

6	Green belt and its significance	**1L**
7	Modelling of greenbelt and plantation design	**1L**
8	Nursery techniques and plantation methods	**1L**
9	Acts and regulations related to carbon credit and green credit, green climate fund	**1L**
10	Preparation of project proposal, procedure for tendering related to carbon credit, central pollution control board, various ministries, their role, activities and schemes	**2L**
11	Organizations, Institutes, NGOs working in the field of carbon credit	**1L**
Credit 2: Environmental Impact Assessment		**15L**
1	Concept, impact analysis, assessment and impact statement	**2L**
2	EIA and its importance in project planning process	**1L**
3	Contents of EIA: project description, anticipated environmental impacts and mitigation measures	**2L**
4	Environmental monitoring programme, project benefits, environmental cost benefit analysis	**2L**
5	Environment attributes: air, water, noise, land and soil	**2L**
6	Monitoring of physical environmental parameters, collection and interpretation of baseline data for various environmental attributes	**2L**
7	Application of various models for prediction of impact on air environment, water environment, noise environment and land	**2L**
8	EIA notification September 2006 and amendments: categorization of projects, procedure for environmental clearance, public participation in environmental decision-making process	**2L**
BOT 571 MJP Practicals based on BOT 564 MJ Carbon Credit and Environment Impact Assessment (2 Credits: 15 Practicals)		
1	Estimation of carbon credit by non-destructive method for determining biomass/carbon assimilation of trees	**2P**

2	Estimation of water and waste management-based carbon credit of campus/society/industry	**2P**
3	Estimation of carbon credit based on air pollution reduction	**1P**
4	Assessment of carbon foot-print of Botanic garden/society/industry	**2P**
5	Demonstration of silviculture practices for green belt development	**3P**
6	Collection and interpretation of meteorological data for baseline study of EIA	**2P**
7	Collection and interpretation of air and noise pollution data	**1P**
9	Assessment of physico-chemical properties of surface and ground water	**2P**
10	Assessment and interpretation of soil quality baseline data	**1P**
11	Collection and interpretation of baseline ecological and biodiversity data	**1P**
12	Case studies on EIA for industries and infrastructure projects	**2P**
BOT 565 Millet-based Nutraceuticals (2 Credits: 30 Lectures)		
Credit1: Introduction to millets		
1	Classification: major, minor, pseudo-millets	**2L**
2	Global scenario of millet cultivation, millet producing states in India, millet map of India, Indian Knowledge System (IKS): Description of medicinal and health benefits of millets in Ayurvedic texts (balancing *doshas*)	**4L**
3	Cultivation practices of millets in India: broadcasting, transplanting, inter-cropping etc., major pests and pathogens, control measures	**2L**
4	Nutritional parameters (dietary fiber, proteins, carbohydrates, lipids, vitamins, micronutrients etc.) of different millets and their comparison with other cereals	**2L**
5	Millets in the Indian rural and urban diet, consumption preferences, role of millets in reducing nutrient deficiency	**2L**

6	Agronomic trait improvement in millets, nutrigenomics and nutrigenetics	**3L**
Credit 2: Nutraceutical value of millets		
1	Introduction to nutraceuticals, formulations, plant-based nutraceuticals	**3L**
2	Overview of polyphenol, flavonoid, phytic acid, carotenoid, tocopherol, phytosterol, arabinoxylan content in millets	**3L**
3	Health benefits of millets: strengthening bones, positive effect on nervous system, maintaining cardiac health, managing type-II diabetes, lowering cholesterol, promoting immunity etc.	**3L**
4	Anti-oxidant and anti-aging properties of finger millet	**1L**
5	Processing of millets: dehusking/decortication, milling, soaking, germination, malting, fermentation, cooking, roasting etc.	**3L**
6	Start-up opportunities: manufacturing value-added products, branding, product development and marketing	**2L**

Suggested References

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BOT 572 MJP Practicals on BOT 565 Millet-based Nutraceuticals
(2 Credits: 15 Practicals)

1	Estimation and comparison of total carbohydrates from finger millet and little millet	**2P**
2	Estimation of total nitrogen from finger millet by the Kjeldahl method	**2P**
3	Estimation and comparison of total lipid content in different millets	**2P**
4	Estimation of reducing sugars, total fibre and ash content in little millet	**2P**
5	Estimation of Fe, Ca, Mg in red and white landraces of finger millet	**2P**
6	Processing of millets for manufacturing value-added products (extruded snacks, noodles, flakes etc.) and assessment of their sensory attributes	**3P**
8	Malting of finger millet grains to prepare 'ragi-malt' and its nutritional analyses	**2P**
9	Visit to a millet-based local industry/minor millet cultivation in a tribal area	**2P**
BOT 566 MJ Aromatic Plants (2 Credits: 30 Lectures)		
Credit 1: Aspects and Prospects		
1	Aromatic Plants: Introduction, Diversity, Aspects and Prospects	**2L**
2	Commercial names, Sources, Major Volatile Compounds	**2L**
3	Aromatic Herbs in Food	**1L**
4	Bioactive Compounds, Processing, and Applications	**2L**
5	Properties of bioactive compounds, recovery and applications	**1L**
6	Spices and Condiments- Diversity, Cultivation and Utilization	**2L**
7	Application of essential oil- Aromatherapy, Aromatics, Perfume, Room Freshener, Deodorants, Cosmaceuticals, medicines, mosquito repellent, etc	**4L**
8	Aroma mission, Government schemes, Processing unit	**1L**

Credit 2: Cultivation, processing and marketing

1	Agro-techniques for commercially important aromatic crops found in various agro climatic regions (comparative account)	**5L**
2	High yielding varieties and their characteristics	**1L**
3	Processing, extraction technologies, green extraction technologies, encapsulation of recovered bioactives	**5L**
4	Aromatic trade: documentation, sources, markets	**1L**
5	Establishment of processing unit:procedure, cost and requirements	**1L**
6	Packaging, Trademark, Value addition, Marketing	**2L**

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BOT 573 MJP Practicals based on BOT 566 MJ Aromatic Plants

1	Identification of aromatic plants including spices	**2P**
2	Identification of raw material and various value-added products	**2P**
3	Nursery techniques for propagation of citronella, vetiver, palmarosa and geranium	**2P**
4	Agrotechniques of commercially important aroma crops	**5P**
5	Lab and commercial scale extraction methods of essential oils	**3P**
6	GC-MS analyses of lemon grass/mint/geranium/vetiver	**3P**
7	Preparation of value-added products such as perfume, room freshener, deodorants, mosquito-repellent	**4P**
8	Project proposal writing, bank loan procedure	**2P**
9	Exposure to trading, wholesale and retail market	**2P**
10	Visits to processing industry/field	**4P**

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BOT 581 **OJT/FP**	**On Job Training (OJT)/Field Project/FP**	**4C**