

Syllabus
As per National Education Policy- 2020

M.Sc. Medicinal and Aromatic Plants



**High Altitude Plant Physiology Research
Centre , H.N.B. Garhwal University**

M.Sc. Medicinal and Aromatic Plants Syllabus

Under NEP 2020

P.G. First Year (for Two-year P.G. program)

First Semester for 2-year P.G. program

(For practical based subjects)

Entry requirement	3-year Bachelor's degree (minimum 120 credits) or 4-Year Bachelor's Degree (In case of B.Tech and B.E programme- Minimum-160 credits) and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations.				
Semester	Course category	Course title	Credits		Total Credit
			T	P	
I	Discipline Specific Core	DSC-1 (Introduction to Medicinal and Aromatic plants)	5	-	5
		DSC -2 (Traditional System of Medicine & Intellectual Property Rights)	5	-	5
		DSC -3 (Plant Physiology, Growth and Development)	5	-	5
		DSC Practical (Practical Approaches in Medicinal Plant Identification, Conservation, and Propagation)	-	3	3
	Discipline Specific Elective (Any 1 out of Minimum 2 electives)	DSE MAPs production OR	4	2	6

		Plant Systematics and Conservation)			
Total			19	5	24

Note: 1. In lieu of elective (Theory and practical= 4+2 credits) the departments may offer any one course i.e. dissertation/project work of 6 credits

2. In lieu of only Elective Practical (2 credits) the departments may offer 2 credit additional course (Field work/Project).

Second Semester for 2-year P.G. program

(For practical based subjects)

Semester	Course category	Course title	Credits		Total Credit
			T	P	
II	Discipline Specific Core	DSC-1 Post-Harvest Technology)	5	-	5
		DSC -2 (Quality control and Phytochemical methods)	5		5
		DSC -3 (Introductory Biochemistry)	5	-	5
		DSC Practical	-	3	3
	Discipline Specific Elective (Any 1 out of Minimum 2 electives)	DSE (Pharmacognosy or Agrotechniques Of MAPs)	4	2 MOOC Course	6
Total			19	5	24

NHEQF Level-6	<i>Student on exit after successfully completing first year of two-year PG programme (i.e., securing minimum required 48 credits will be awarded “Postgraduate Diploma” of one year, in related field/discipline/subject.</i>
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Note: 1. In lieu of Discipline elective (Theory and practical= 4+2 credits) the departments may offer any one course i.e. dissertation/project work of 6 credits

2. In lieu of only Discipline Elective Practical (2 credits) the departments may offer 2 credit additional course (Field work/Project/Swayam course).

Third Semester for 2-year P.G. program

(For practical based subjects)

Semester	Course category	Course title	Credits		Total Credit
			T	P	
III	Discipline Specific Core	DSC-1 (Introductory Herbal Biotechnology)	3	2	5
		DSC -2 (Integrated Plant Protection)	3	2	5
		DSC -3 (Research Methodology and Introductory Biostatistics)	3	2	5
		DSC Practical (Research Methodology	-	3	3

		and Scientific Writing)			
	Discipline Specific Elective (Any 1 out of Minimum 2 electives)	DSE-2 (Medicinal plants case studies or Organic and Protected Cultivation or Marketing of MAPs)	4	2 (Field work/Community engagement)	6
Total			19	5	24

Note: 1. In lieu of elective (Theory and practical= 4+2 credits) the departments may offer any one course i.e. dissertation/project work of 6 credits

2. In lieu of only Discipline Elective Practical (2 credits) the departments may offer 2 credit additional course (Field work/Project/Swayam course).

Fourth Semester for 2-year P.G. program

(For practical based subjects)

Semester	Course category	Course title	Credits		Total Credit
			T	P	
IV	Discipline Specific Core	DSC-1 (Herbal Chemistry)	5	-	5
		DSC -2 (Propagation & Nursery Management)	5		5

		DSC -3 (Bioresources Management)	5	-	5
		DSC Practical (Techniques in Herbal Product Development and Standardization)	-	3	3
	Discipline Specific Elective (Any 1 out of Minimum 2 electives)	DSE-2 (Dissertation or Processing Technology of Aromatic Plants or Ethnobotany)	4	2	6
Total			19	5	24
NHEQF Level- 6.5	<i>Student on successfully completing two-year PG programme (i.e., securing minimum required 96 credits will be awarded "Postgraduate Degree", in related field/discipline/subject.</i>				

Note: 1. In lieu of elective (Theory and practical= 4+2 credits) the departments may offer any one course i.e. dissertation/project work of 6 credits

2. In lieu of only Discipline Elective Practical (2 credits) the departments may offer 2 credit additional course (Field work/Project/Swayam course).

Note: Out of the courses offered across the four semesters of 2-year P.G. programme, in each semester, at least two courses should be skill-based. If the department is unable to offer the minimum of two skill-based courses in a given semester, it may compensate by offering additional/extra skill-based courses in the other semester."

Note: Research based courses such as Research methodology, Research writing and ethics, project work, dissertation, field visit, community engagement etc may be offered in the P.G. programme.

First Semester for 2-year P.G. program

DSCI. Introduction to Medicinal and Aromatic plants

Credits: 3+2

Unit - I

MAPs: definition, history, importance and future prospects. Medicinal Plants – past and present status in world and India. MAPs as industrial crops - constraints and remedial measures. Medicinal plant diversity & local healthcare. Medicinal plant conservation – issues and approaches. Medicinal plant conservation areas (MPCA), Non-timber forest products (NTFP), Good Agriculture and Collection Practices (GACP). Indian Himalayan region (IHR).

Unit - II

Promotion of medicinal plant sector at national level: National Medicinal Plant Board and State Medicinal Plant Boards - objectives and functions. Other organizational initiatives for promotion of MAPs at National and International levels. Demand and supply of medicinal plants. Herbal industries.

Unit-III

Important medicinal plants of India with their systematics, geographical distribution and uses. *Acorus calamus*, *Adhatodavasicca*, *Abrus precatoriu*, *Aloe vera*, *Phyllanthus amarus*, *Stevia rebaudiana*, *Belladonna* and *Cinchona*.

Unit –IV

Important aromatic plants of India with their systematics, geographical distribution and uses. Introduction and historical background of aromatic plants. Aromatic and cosmetic products. Raw material for perfumes etc. Cosmetic Industries. Major, minor and less known aromatic plants of India. Taxonomic descriptions and uses of important aromatic plants – citronella, damask rose, geranium, khus grass, large cardamom, lavender, lemon grass, mentha, holy basil, patchouli, rosemary, Palmarosa, vetiver, artemisia, eucalyptus, thyme, marjoram and oreganum. Aromatic spices - clove, cinnamon, nutmeg, ajwain, dill, celery, tamarind, garcinia, curry leaf and saffron.

Practicals: Identification of 10–15 key medicinal plants, Hands-on identification (*Acorus*, *Aloe*, *Adhatoda*, *Abrus*, etc.), Parts used and medicinal properties. Identification of 10–12 important aromatic plants- Mentha, Citronella, Palmarosa, Vetiver, etc. Organoleptic characters: smell, texture. Group task: Document in-situ and ex-situ strategies, xvCase discussion: MAP conservation from Indian Himalayan Region. Introduction to GACP (Good Agricultural and Collection Practices)- Visit or demo: nursery/field site or simulated protocol design, Study of MAP-based agro-ecosystems: Mini-field survey or secondary data analysis

Suggested Readings:

1. Medicinal Plants of Uttarakhand by C.P. Kala (2010).
2. Indian Medicinal Plants by P.C. Trivedi (2009).
3. Medicinal Plants of Indian Himalaya by S.S. Samant and U. Dhar.
4. Hand Book of Aromatic Plants by S.K. Bhattacharjee (2004).
5. Handbook of MAPs by S.K. Bhattacharjee (2009).

DSCII.Traditional System of Medicine & Intellectual Property Rights

Credits: 4+ 2

Unit - I

Traditional System of Medicine (TSM) in India. Introduction, Concept and Principles of Ayurveda, Siddha, Unani and, Homeopathy; Importance of TSM; Concept and Principles of Naturopathy and Tibetan Medicine; Concept of herbalism and its significance. Introduction to phyto-medicines and herbal raw materials. Local health traditions, ethanomedicines.

Unit – II

Intellectual property rights including patents, copyrights, trademarks, geographical indicators and trade secrets etc. Indian Patent Act, conditions for patenting, provisional and complete specifications,

International and national laws with special reference to patents. IPRs in relation to traditional knowledge and culture; Bio-piracy.

Practicals: Identification and documentation of herbal raw materials used in Ayurveda, Unani, Siddha, and Tibetan systems. Field visit to traditional healers/local health practitioners to document ethnomedicinal knowledge and practices. Demonstration of crude drug evaluation techniques (organoleptic, macroscopic, and microscopic characters). Comparative chart preparation showing the principles and practices of Ayurveda, Siddha, Unani, Homeopathy, Naturopathy, and Tibetan medicine. Preparation of herbarium specimens of selected medicinal plants used in local health traditions. Intellectual Property Rights and Traditional Knowledge: Case study discussion on patenting of herbal drugs and traditional formulations. Practical exercise on searching patent databases (e.g., Indian Patent Office, WIPO, USPTO) for MAP-related patents. Filing procedure for patents – simulation of drafting provisional and complete specifications. Study and interpretation of Indian Patent Act sections relevant to biological material and traditional knowledge. Activity on identifying examples of geographical indications (GI) and trademarks related to medicinal plants/products. Preparation of a report on national and international laws protecting indigenous knowledge.

Suggested Readings:

1. Handbook of Medicinal and Aromatic Plants by S.K. Bhattacharjee (2004).
2. Recent Progress in Medicinal Plants Vol.12, Globalization of Herbal Health by A.K. Sharma (2006).
3. Handbook of Ayurvedic Medicinal Plants by L.D. Kapoor (2005).
4. Indian Medicinal Plants (Vol 1- 4) by K.R. Kirtikar and B.D. Basu (2006).
5. IUCN Red List Categories by IUCN (1993).
6. Indigenous Medicinal Plants Social Forestry & Tribals by M.P. Singh *et al.* (2003).
7. Ayurvedic Drugs and their Plant Sources by V.V. Sivarajan & I. Balachandran, Oxford & IBH (1994).
8. The Handbook of Ayurveda Shantha by Godagama, Bishen Singh Mahendrapal Singh, Dehradun (2004).

DSCIII. Plant Physiology, Growth and Development

Credits: 3+2

Unit 1: Plant Cell and water relations

The plant cell: ultrastructure and functions. Evolution of mitochondria and chloroplasts. Plant water relations, diffusion, osmosis and imbibition. Absorption of water, active and passive absorption, field capacity, wilting coefficient, velamen, aquaporins. Transpiration and guttation. Ascent of sap and vital theories.

Unit 2: Mineral Absorption and Nutrition

Absorption of mineral salts-Ion exchange, passive and active absorption. Transport across membrane: electrochemical potential gradient, influx and efflux, membrane transport proteins, passive transport, primary and secondary active transport (symport, antiport). Mycorrhizae and their role in absorption of minerals in higher plants. Essential and non-essential elements. Major and minor elements. General functions of essential elements, deficiency and toxicity symptoms. Nitrogen metabolism: conversion of nitrates into ammonia. Regulation of nitrate reductase, biological nitrogen fixation and formation of root nodules in leguminous plants.

Unit 3: Photosynthesis

RubisCO: Structure and function. Photosynthetic apparatus. Photosynthetic pigments and absorption of light energy. Two pigment systems. Light reactions: cyclic and non-cyclic electron transport, photophosphorylation and production of assimilatory power. Calvin cycle (C3 cycle), C4-dicarboxylic acid pathway (Hatch-slack pathway). Photorespiration and Glycolate metabolism (C2 cycle). Crassulacean Acid Metabolism (CAM). Comparison between C3, C4 and CAM plants. Factors affecting photosynthesis. Translocation of organic solutes. Special mode of nutrition in angiosperms: parasitic angiosperms.

Unit 4: Growth: Hormones, Photoperiodism, Vernalization and Photomorphogenesis

Growth: definition, regions of growth. Kinetics of growth-course of growth (sigmoid curve), absolute growth rate, relative growth rate. Natural growth hormones in plants: their discovery, chemical nature, physiological effects, distribution, biosynthesis, destruction/inactivation. Photoperiodism: Photoperiodic induction and perception, florigen, and phytochrome. Vernalization: perception and necessary conditions, de-vernalization. Floral evocation and flower development. Circadian rhythms and biological clock. Fruit ripening: role of ethylene and hormonal control. Abscission of leaves. Senescence and programmed cell death (PCD). Phytochrome and Cryptochrome mediated responses in plants.

Unit 5: Stress Physiology

Water deficit and drought resistance. Salt stress and salt resistance. Cold injury and cold resistance: Chilling and freezing. Heat stress and heat resistance. Heavy metal stress and resistance. Biotic stresses in plants: hypersensitive response, secondary acquired resistance (SAR), Jasmonates and salicylic acid. Major secondary metabolites and their role in stress physiology in plants.

Practicals:

Study of Plant Cell and Ultrastructure :Observation using compound microscope and diagrams (onion peel, chloroplasts, mitochondria), Determination of Water Potential / Osmotic Potential of Plant Tissue, Experiment on Imbibition and Its Rate in Seeds, Demonstration of Transpiration and Guttation in Plants, Preparation of Nutrient Solutions (Hoagland's solution), Making and adjusting nutrient solutions in lab. Enzyme-based assay demonstration or data analysis. Pigment Separation and analysis, Chlorophyll a, b, and carotenoids separation, Gaseous Exchange Measurement using IRGA, Chlorophyll Fluorescence measurement. Bioassay of Plant Hormones, Measurement of Growth Parameters in Seedlings Root and shoot length, fresh and dry weight of the various growth hormone
Study of Photoperiodism and Vernalization (Concept + Simulated Activity,
Extraction and Estimation of Proline, Lipid Peroxidation, Antioxidants.

Suggested readings:

1. Salisbury, F.B. and Ross, C.W.: Plant Physiology,
2. Hartmann, H.T & Kester, D.E (1989). *Plant Propagation – Principles and Practices*. Prentice Hall of India
3. Hudson: Plant propagation principles and practices

DSC Practical: Practical Approaches in Medicinal Plant Identification, Conservation, and Propagation Credit: 3

Unit 1

Plant Identification: Identification of selected medicinal plants using live specimens, seeds, and plant structures. Utilization of floras and taxonomic keys. Hands-on identification using fresh samples and dichotomous keys. Preparation of transverse sections (T.S.) and longitudinal sections (L.S.) of medicinal and aromatic plants (MAPs). Preparation of leaves, stems, and roots slides. Powder microscopy of crude drug samples. Microscopical evaluation of plant drugs (at least five) listed in theory- Vein islet number, vein termination number, stomatal index, stomatal number, palisade ratio, trichomes, starch grains, calcium oxalate crystals).

Unit 2

Ecological Practices and Biodiversity: Habitat surveys and mapping the occurrence of selected medicinal plant species. Recording altitude, slope, aspect, soil type, and associated vegetation. Distribution patterns (random, uniform, clumped) using the quadrat method. Map and GPS tag local populations of key medicinal and aromatic plants (MAPs).

Unit 3

Preservation Techniques: Preparation of herbarium and crude drug samples. Creation of at least 10 herbarium sheets of medicinal plants. Submission of 10 authenticated crude drug samples with appropriate labels. Conduct macroscopic and microscopic evaluations. Preparation of a field report including images and app-based identification notes.

Unit 4

Conservation and Propagation Practices: Field visits to in-situ conservation sites and community

forests. Demonstration of sustainable harvesting methods for roots, rhizomes, and leaves. Organic nursery cultivation of MAPs. Documentation of traditional conservation practices (local community knowledge). Preparation of ecological fact sheets for 3-5 RET medicinal plants. Seed collection, extraction, cleaning, and storage. Seed germination testing (standard test protocols). Use of seed treatments (scarification, stratification, growth regulators). Seedling raising in polybags, root trainers, and beds. Vegetative propagation methods: Cutting (softwood, hardwood), layering, grafting. Rhizome and bulb propagation techniques. Media preparation: Sand, soil, cocopeat, vermicompost, perlite mixtures.

DSE1-MAPs production Credits: 4+2

Unit 1

Introduction, life cycle in plants, Plant propagation: Different methods of propagation; Sexual and Asexual modes of propagation; Seed production; germination process and environmental factors affecting it, quality of seeds, seed dormancy, treatments to facilitate germination, seed testing. Vegetative propagation- Cutting, budding, grafting and layering. Micro-propagation. Apomixis, polyembryony. Micro propagation: Introduction, objectives, merits and demerits, facilities and equipments, aseptic techniques and use of antibiotics, media preparation, micro propagation techniques- clonal propagation, direct organogenesis, embryogenesis, meristem culture, micro grafting, hardening, packing and transport of micro-propagules.

Unit II

Field preparation and plot designing, spacing, earthing etc. Systems of cultivation; High density cultivation; Different cropping systems in MAPs; Production and training in MAPs. Biofertilizers, vermicompost and organic farming; Role of plant growth regulators with special reference to MAPs; Integrated nutrient management; Weed management; Irrigation systems.

Unit III

Origin and distribution, compositions and uses, species and cultivars, Soil, climate, irrigation and nutrition requirement, Maturity and harvesting, Pests and diseases of Aconites, *Rhubarb*, *Dioscorea*, *Gloriosa superba*, *Andrographis paniculata*, *Catharanthus roseus*, *Catharanthus roseus*, Ashwagandha, Pattharchoor, Ocimum.

Unit IV

Importance, origin and distribution, classification, varieties, climate and soil requirements, propagation and nursery techniques, maintenance of nursery, methods of planting, cultural practices, nutrition and water requirements, plant protection and management, harvest indices and harvesting; processing of ginger, turmeric, cardamom and vanilla.

Practicals: Plant Propagation and Micropropagation: Study of plant life cycle stages using selected MAPs. Demonstration and practice of sexual and asexual propagation methods, Seed viability and germination tests under different environmental conditions. Demonstration of seed dormancy-breaking techniques (mechanical and chemical treatments). Micropropagation techniques: clonal propagation, meristem culture, organogenesis, embryogenesis. Field layout and plot designing for MAP cultivation. Demonstration of different spacing, earthing-up, and cropping systems. Application of biofertilizers, vermicompost, and organic manures. Irrigation system demonstration: drip, sprinkler, and furrow systems. Propagation and nursery raising of selected MAPs. Cultural practices and nutrient management in spice MAPs. Visit to MAP nursery, processing unit, or herbal industry for hands-on exposure.

Suggested Readings:

1. Cultivation of Medicinal and Aromatic Plants by A.A. Farooqi (2004).
2. Medicinal Plants Cultivation: A Scientific Approach by S.S. Purohit (2004).
3. Agro techniques of High Altitude Medicinal and Aromatic Plants by M.C. Nautiyal and B.P. Nautiyal (2004).
4. Cultivation of Tropical, Sub Tropical Vegetables, Spices, Medicinal and Aromatic Plants by NIIR (2005).
5. Cultivation and Utilization of Aromatic Plants by Atal and Kapoor.
6. A Handbook of Organic Farming by A.K. Sharma (2004).

DSE2.Plant Systematics and Conservation

Credits: 4+2

Unit-I

Concept of taxonomy, keys and classification based on botanical features and official parts. Study of plant parts (microscopic and macroscopic) based on morphological features. Modern concept of taxonomy-Chemotaxonomy and Molecular taxonomy-applications.

Unit-II

Botanical description of selected types (microscopic and macroscopic characteristics). Botanical and economical classification of medicinal & aromatic plants. Preparation of herbaria and useful herbarium notes concerning individual plant species. Study of herbaria in relation to MAPs. Famous Indian and World herbaria.

Unit-III

Natural status of the species, Habitat fragmentation, speciation, population concept, mapping of the populations, morphological and genetic diversity. Conservation genetics. Conservation methods- *ex situ* and *in situ*. genebanks, botanical gardens, Global concerns for conservation of MAPs, Biodiversity hot spots-India. Should be in Bioresource managements.

Practicals: Field surveys for familiarization with local plants. Collection of specimens. Description based on field characters, identification, preparation of herbarium specimens. Field visits.

Suggested Readings:

1. Medicinal Plants: Conservation Cultivation & Utilization by A.K. Chopra, Daya publishing house, Trinagar, Delhi (2007).
2. Principles and practice of plant conservation by D.R. Given, Timber Press, The University of Michigan (1994).
3. Plant Diversity and Conservation in India an overview by H.J. Chowdhery, Bishen Singh Mahendrpal Singh, Dehradun (2000).
4. Himalayan Biodiversity Conservation Strategies by U. Dhar, GBPIHED, Kosi-Almora (1993).
5. Biodiversity: Strategies for Conservation by L.K. Dadhich (2002).

Second Semester for 2-year P.G. program

DSC -I Post-Harvest Technology

Credits: 4+2

Unit - I

Scope and importance of post harvest technology. Post-harvest handling of wild and plantation crops of MAPs. Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes. Post harvest losses.

Unit - II

Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage ventilated, refrigerated, MAS, CA storage. Pre-cooling, sorting & grading, packaging, transportation and marketing. Cool chain. Preservation-principles and practices for MAPs. Semi processing, adulteration, packaging and labeling.

Unit - III

Harvesting, grading and storage of medicinal plants. Post harvest handling of aromatic plants. Different methods of essential oil extraction and their drying and storage. Active content dynamics

vis-a vis plant growth and post-harvest processing for evaluation of chemical constituents. Influence of post harvesting practices on active principles of MAPs.

Unit – IV

Drying: introduction, drying and dehydration, osmotic drying, vacuum drying and freeze drying. Dried and dehydrated products. Enzymatic browning. Irradiation for control of spoilage during storage and transit. Value addition and Value added products. Safety standards.

Practicals: Identification of maturity indices for selected MAPs, Demonstration and practice of harvesting techniques (Manual and mechanical harvesting, Market-specific harvesting practices) Assessment of post-harvest losses. Study of enzymatic and textural changes during post-harvest period: Enzymatic browning demonstration (e.g., in turmeric or ginger), Softening and lignification in herbs (e.g., *Bacopa*, *Centella*). Pre-shipment treatment methods, Demonstration of different storage methods. Sorting, grading, packaging, and labeling of MAPs (Manual grading of dried MAPs, Designing labels as per FSSAI/AYUSH regulations). Study of adulteration in MAPs: Identification of common adulterants in powdered and raw drugs. Post-harvest handling of selected aromatic crops. Drying and storage of essential oil-bearing plants.

Suggested Readings

1. Advances in Horticulture. Vol. IV; by K.L. Chadha & O.P. Pareek (Eds.), Malhotra Publ. House (1996).
2. Post Harvest Physiology and Handling of Fruits and Vegetables by N.F. Haid & S.K. Salunkhe, Grenada Publ (1997).
3. Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits by S.K. Mitra, CABI (1997).
4. Post Harvest Technology of Horticultural Crops by K.P. Sudheer & V. Indira, New India Publ. Agency (2007).
5. Post Harvest. An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals by R. Willis, W.B. Mc Glassen, D. Graham & D. Joyce, CABI (1998).
6. Post Harvest Technology of Fruits and Vegetables, Handling, Processing, Fermentation and Waste Management, Vol I & II by Verma and Joshi (2000).

DSCII. Quality control and Phytochemical methods

Credits: 3+2

Unit-I

Drug examination; Macroscopic and Microscopic evaluation; Moisture content; Microbial Infestation; Contaminations and Aflatoxins; Development of standard parameters; Solvent extractive values; Ash values; Crude fiber; Bitter value, Foaming index, Swelling index, Heavy metals.

Unit-II

Adulteration and deterioration- Quality Control, Quality Assurance and Stability testing, Physical quality assurance, Good Manufacturing Practices; Good Laboratory Practices, Validation; Marker compound evaluation. International regulations and guidelines for MAPs quality control (e.g., WHO, USP, Pharmacopoeias). Compliance with legal requirements and documentation in MAPs quality control.

Unit-III

Methods of isolation; Extraction methods; Thin layer chromatography; HPTLC; Column Chromatography; HPLC; Gas Chromatography; Methods of characterization; Spectroscopic methods, UV, Visible, IR, NMR, Mass Spectrometry, Atomic absorption/ ICP/ICP-MS, GC-MS, LC-MS.

Practicals:

Macroscopical and microscopical evaluation including quantitative microscopy. Physical, Chemical and Biological evaluation in quality control of crude drugs. Estimation of plant phytoconstituents using modern methods like UV and HPTLC, HPLC etc. Adulteration and Quality Assurance: Identification of adulterants through organoleptic and microscopic evaluation, Case study-based practical on

adulteration and deterioration in MAPs. Preparation of standard operating procedures (SOPs) as per GMP guidelines. Documentation practices as per GLP (Good Laboratory Practices).

Spectroscopic Characterization (Demo-Based or Instrument Access): Demonstration of UV-Vis Spectrophotometry: analysis of herbal constituents. Overview of Mass Spectrometry, GC-MS, LC-MS and Atomic Absorption/ICP techniques (industrial/institutional demo or case-based discussion).

Suggested readings

1. Direct uses of medicinal plants and their identification by Vardhana, Sarup and Sons, Ansari Road, Dariyaganj, New Delhi (2008).
2. Utilization and management of MAPs by V.K. Gupta.
3. Evaluation of herbal medicinal products by Houghton.
4. Pharmacognosy by C.K. Kokate.
5. Medicinal plants, applied biology of domestication and export by K. Singh, S.K. Tyagi, Bishen Singh Mahendrapal Singh Dehradun.
6. Quality Control Methods for Medicinal Plants Materials, W.H.O. (1998).

DSCIII. Introductory Biochemistry

Credits: 3+2

Unit-I

Scope and importance of biochemistry: Biochemistry as modern science and its various divisions, Scope and importance of biochemistry in agriculture and allied sciences. Foundation of life: Fundamental principles governing life, supramolecular structures, significance of weak non covalent interactions in biology, Water: Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship. Physical techniques for structure determination: General introduction to physical techniques for determination of structure of biopolymers.

Unit II

Structure And Function of Biomolecules- Biomolecules: Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids. Immunoglobulins and PR proteins, Structure, formation and different forms of immunoglobulins, PR proteins and their classification. Plant secondary metabolites: Structure, classification and function of plant secondary metabolites.

Unit III

Metabolism- Molecules aiding metabolism: Structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Thermodynamics –principles and energetic of life, Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Unit IV

Catabolism and its Regulation- Catabolism of energy molecules: Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation. Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic theory and proton motive force.

Practical

Preparation of buffers and measurement of pH: Use of pH meter, Preparation of buffer solutions at various pH levels, Determination of pKa of a weak acid using titration curves

UV-Visible Spectrophotometry: Calibration and operation, Determination of λ_{max} for a given compound. Introduction to structure determination techniques (Demonstration or simulation): Basics of X-ray crystallography, NMR, Mass spectrometry (video modules or software tools)

Biomolecules and Plant Secondary Metabolites: Qualitative and quantitative tests for carbohydrates, proteins, amino acids, lipids and nucleic acids. Extraction and estimation of plant secondary metabolites: Alkaloids, flavonoids, phenolics (simple methods). Enzyme assays, Thin Layer Chromatography (TLC) of plant pigments or amino acids. Demonstration of aerobic respiration in seeds (O_2 uptake measurement)

Suggested Reading

1. Lehninger Principles of Biochemistry – Nelson & Cox. Comprehensive and authoritative;

- ideal for understanding core biochemical processes.
2. Biochemistry – Lubert Stryer. Visually rich and conceptually clear; very good for enzyme mechanisms, metabolism, and molecular biology.
 3. Biochemistry – U. Satyanarayana & U. Chakrapani. Simplified for students of agriculture, pharmacy, and life sciences; includes clinical correlations.
 4. Fundamentals of Biochemistry – J.L. Jain, S. Jain, N. Jain. Covers basics in a straightforward manner; Indian context with agricultural examples.
 5. Outlines of Biochemistry – E.E. Conn, P.K. Stumpf, G. Bruening, R.H. Classic text with emphasis on plant and microbial biochemistry.
 6. Plant Biochemistry – Hans-Walter Heldt & Birgit Piechulla. Detailed insights into plant metabolic pathways, photosynthesis, secondary metabolites.
 7. Biochemistry and Molecular Biology of Plants – Bob Buchanan, Wilhelm Gruissem, Russell Jones. In-depth for advanced topics, especially in plant systems.

DSC Practical: Analytical Methods in Medicinal Plant Research

Credit 3

Unit I

Comparative Conventional Extraction Techniques-Maceration, infusion, decoction, and percolation on a designated plant material using different solvents. Calculation of percentage yield of dried extract. Comparing qualitative phytochemical profile using TLC.

Hot Continuous Extraction (Soxhlet)- Set up and operation of a Soxhlet extraction apparatus with a selected plant material and solvent. Determination of percentage yield of the extract.

Hydrodistillation for Essential Oils (Clevenger apparatus)- Isolation of essential oil from an aromatic plant material using a Clevenger-type apparatus. Calculation of yield and recording of physical characteristics.

Unit II

Qualitative Phytochemical Screening of Extracts-To Perform a series of chemical tests on prepared extracts to detect major classes of secondary metabolites (alkaloids, glycosides, flavonoids, tannins, saponins, terpenoids, steroids). Recording observations and inferences. Determination of Acid Value, Saponification Value, and Iodine Value of a provided fixed oil sample. Introduction to UV-Vis spectrophotometer operation. Record UV-Vis spectrum of a standard compound and determine its λ_{max} . Prepare a calibration curve for a standard compound by measuring absorbance at λ_{max} . Determine the concentration of the compound in an unknown solution or diluted herbal extract. (Optional: Estimate Total Phenolic/Flavonoid Content).

Unit III

Thin Layer Chromatography (TLC): Separation and Identification: Separation of a mixture of known phytoconstituents or plant extract components by TLC using pre-coated silica gel plates and different solvent systems. Calculation of R_f values and identification of components by comparison with standards. TLC: Effect of Solvent Polarity and Visualization-Investigation of the effect of varying mobile phase polarity on separation and R_f values. Practice visualization under UV light (254/366 nm) and with general/specific spray reagents. High-Performance Thin Layer Chromatography (HPTLC): Familiarization and Fingerprinting: Introduction to HPTLC system components and operation. Develop an HPTLC chemical fingerprint for a selected herbal drug or formulation, optimizing parameters. Analysis of chromatograms.

Unit IV

High-Performance Liquid Chromatography (HPLC): Familiarization and Mobile Phase Preparation- Introduction to HPLC system components (pump, injector, column, detector), software, and maintenance. Practice preparing, filtering, and degassing mobile phases. Method Development Basics (Standard)- Using a known standard, investigate the effect of mobile phase composition, flow rate, and detection wavelength on retention time, peak shape, and resolution in RP-HPLC. HPLC: Qualitative and Quantitative Analysis. Familiarization and Analysis of Essential Oil- introduction to GC system components (injector, oven, column, FID), software. Inject a diluted essential oil sample and identify major components by retention times (and MS library if GC-MS). GC: Effect of Temperature Programming- Demonstration and comparison of isothermal vs. temperature-programmed elution on

the separation of a complex mixture with a range of boiling points.

Theoretical concepts of metabolomics (targeted/untargeted), analytical platforms (LC-MS, GC-MS, NMR), and principles of chemometric methods (PCA, PLS-DA, HCA). Optional hands-on session with software (e.g., MetaboAnalyst) using sample datasets. Analysis of published metabolomic studies.

DSE1. Pharmacognosy

Credits: 4+2

Unit-I

History, definition and scope and future of Pharmacognosy. Traditional and alternative systems of medicine. Classification and pharmacognostic studies of crude drugs.

Unit-II

Analytical Pharmacognosy-drug adulteration, methods of drug evaluation, biological testing of herbal drugs, phytochemical investigations, Antimicrobial activity of plant extract.

Unit-III

Ayurvedic Pharmacy, drugs of mineral origin, natural pesticides its classification, factor influencing the development of natural pesticide, antibiotics and its mechanism of action and allergenic extracts. Drugs containing glycosides, tannins, terpenoids, Enzyme and protein drugs, Alkaloidal drugs. Phytopharmaceuticals, nutraceuticals and cosmeceuticals.

Unit-IV

Introduction to different dosage forms and methods of preparation of Homeopathy and Unani medicines. Study of information retrieval methods of natural plants and herbal data base. Phytochemical and Pharmacological literature review of *Gymnemasylvestre*, *Azadirachta indica*, *Adhatodavasica*, *Asparagus racemosus*, *Commiphora mukul*, *Podophyllum hexandrum*, *Ocimum sanctum*, *Shankapushpi* and *Tylophoraasthamatica*.

Practicals:

Different methods of drug identification and evaluation, biological testing of herbal drugs. Visit to practitioner of traditional and alternative systems of medicine

Suggested Readings:

1. Pharmacognosy by Handa.
2. Pharmacognosy by Wallis.
3. Pharmacognosy by Kokatae, Purohit and Gokhle (2002).
4. Textbook of Pharmacognosy by Tyler, Brady and Robbins.
5. Textbook of Pharmacognosy by Trease and Evans.
6. Pharmaceutical Dosages Forms by L. Lachman & J.B. Schwartz, (Vol I, II, III) (1989).
7. Evaluation of Phyto-pharmaceuticals by Turner.
8. Textbook of Pharmacognosy by Shah and Qadry.
- 9.

DSE II. Agrotechniques of MAPs

Credits: 3+2

Unit I

Good cultivation and harvesting practices, WHO, NMPB and AYUSH guidelines on GACPs, Factors influencing the selection of medicinal plant species, Criteria for selecting suitable plant species, Soil requirements for medicinal plant cultivation, Soil testing and analysis, Soil preparation techniques, Soil amendment and fertility management.

Unit II

Site selection and land preparation, Planting techniques and spacing, Irrigation methods and scheduling, Nutrient management and fertilization, Weed control measures, Pest and Disease Management, Identification of harvesting period based on active content. Harvesting method of underground parts, leaves, stem, bark, fruits, flowers etc.

Unit III

Detailed study of origin and distribution, economic importance, classification, varieties, climate and soil requirements, propagation and nursery techniques. Maintenance of nursery, methods of planting, cultural practices, nutrition and water requirements, plant protection and management, harvesting and yield of *Picrorhizakurrooa*, *Pseudogenseng*, *Chlorophytum*. etc.

Unit – IV

Importance, origin and distribution, classification, varieties, climate and soil requirements, propagation and nursery techniques, maintenance of nursery, methods of planting, cultural practices, nutrition and water requirements, plant protection and management, harvest indices and harvesting; processing of ginger, turmeric, cardamom and vanilla, garlic, jamboo.

Unit – V

Economic importance, classification, improved varieties, climate and soil requirements, propagation and nursery techniques, sowing, seed rate, time of sowing, methods of planting, cultural practices, nutrition and water requirements, plant protection and management, harvesting, yield and processing of coriander, fenugreek, fennel, cumin and *Carum carvi*.

Practicals: Demonstration of WHO/NMPB/AYUSH guidelines on Good Agricultural and Collection Practices (GACPs). Exercise on selection of medicinal plant species based on local agro-climatic conditions and demand. Soil sampling and testing: pH, EC, organic carbon, NPK. Practical on soil preparation, tillage operations, and use of soil amendments. Plot layout and site preparation for MAP cultivation. Demonstration of nursery raising techniques and transplanting. Methods of irrigation and scheduling: drip, sprinkler, surface irrigation. Application of organic and inorganic fertilizers (INM practices). Identification and mechanical/manual weed management practices. Pest and disease identification and eco-friendly control measures. Identification of maturity indices and demonstration of harvesting techniques for different plant parts (root, stem, bark, leaves, flowers, fruits, seeds). Agrotechniques for the selected MAPs.

Suggested readings

1. Commercially important medicinal and aromatic plants of Himachal Pradesh by P.B. Singh (1999).
2. Agrotechniques for high altitude medicinal and aromatic plants by M.C. Nautiyal and B.P. Nautiyal, Bishen Singh Mahendrapal Singh Dehradun (2004).
3. Medicinal plant cultivation and their uses by H. Panda, National Institute of Industrial Research (2002).
4. Cultivation and Utilization of Medicinal and Aromatic Crops by C. Atal & V. Kapoor, CSIR (1992).
5. Cultivation and Utilization of Aromatic Plants by C.K. Atal & B.M. Kapur, CSIR, RRL, Jammu (1982).
6. Production Technology of Medicinal and Aromatic Crops by A.A. Farooqi, M.M. Khan & M. Vasundhara, Natural Remedies Pvt. Ltd. (2001)..

SWAYAM MOOC Course in place of practical of the Elective course (2 Credit)

DSCI. Introductory Herbal Biotechnology

Credits: 3+2

Unit-I

Biotechnical advances in medicinal plants; Basic tools and technology for Molecular Herbal Biotechnology; basic concepts of genetic engineering, gene bank and gene pool; concepts and basic techniques in plant tissue culture. Genetic transformation and secondary metabolite production.

Unit-II

In vitro evaluation methods for herbal drug action using molecular biotechnological tools; *In vitro* culturing of medicinal plants and production of herbal drugs. Hairy root cultures and bioreactors.

Unit-III

Application of molecular biology tools for the improvement, production, characterization, purification and identification of therapeutically useful phyto-constituents; influence of bioregulators, effect of differentiation, techniques of elicitation for production of secondary metabolites.

Practicals:

Establishment of *in vitro* cultures of MAPs. Novel extraction techniques of phytochemicals. *In vitro* evaluation of phytochemicals.

Suggested Readings:

1. Role of Biotechnology in Medicinal and Aromatic Plants (Vol 1-13) by I.A. Khan (1999).
2. Medicinal Plants Biotechnology by Veeresham (2006).
3. Biotechnology in Horticulture and Plantation Crops by K.L. Chadha, P.N. Ravidran and L. Sahijram (2000).
4. Biotechnology: Fundamentals and Applications by S.S. Purohit (2002).
5. Handbook of Biotechnology by A.L. Bhatia.
6. A Handbook of Biotechnology Vol 1-4 by N. Yadav.

DSCII. Integrated Plant Protection

Credits: 3+2

Unit-I

Classification of pests, Introduction to principles of integrated plant disease management in MAPs. Economic threshold. Relationship of environmental factors with disease development. Importance and benefits of integrated plant protection approaches.

Unit-II

Plant quarantine, eradication, protection, and disease resistant strategies against important diseases. Biological and biotechnological approaches in disease management., Genetically modified crops.

Unit-III

Scope and importance of integrated pest management (IPM). Tools of pest management, their description and usage in IPM programmes. Insect pests of important medicinal and aromatic crops, their biology, nature, extent of damage and their management.

Unit-IV

Weeds – types and classification; invasive species; weed control, common weeds of important medicinal plants. Integrated weed management (IWM). Emerging Technologies in Plant Protection, Role of remote sensing and GIS in pest monitoring, Precision agriculture and sensor-based technologies.

Practicals: Identification and classification of pests and disease-causing organisms in MAPs, Observation of disease symptoms in major medicinal and aromatic crops. Case study analysis on

integrated disease management approaches. Visit to a plant quarantine station or virtual tour to understand quarantine procedures. Demonstration of seed/plant material treatment methods for pathogen eradication. Identification of insect pests of key MAPs. Study of pest biology, nature and extent of damage through field or lab observation. Installation and use of IPM tools, Preparation and application of botanical pesticides and biopesticides. Preparation of an IPM module for selected MAPs. Identification and classification of common and invasive weeds in MAP cultivation. Hands-on weed control practices: mechanical, manual, and chemical methods. Preparation of an Integrated Weed Management (IWM) plan for MAPs. Use of mobile apps or precision agriculture tools (if available) for pest detection and monitoring.

Suggested readings:

1. Biopest management by Gupta.
2. Insect and Mites infesting Medicinal plants in India by S.K. Gupta, Bishen Singh Mahendrapal Singh Dehradun.
3. Plant Diseases and their Biological Control by Singh, Mallika books 348, Santnagar, Delhi.
4. Bioagents in Plant disease management by Trivedi, Mallika books 348, Santnagar, Delhi.
5. Biologocal Controls of Plant parasitic Nematodes by Rajendra.
6. Biofertilizers and Biopesticides by S. Suri.
7. Plant diseases management in Horticultural Crops by S. Ahmed.
8. Insect Pest and their Control by J.W.E. Evans, Samir book centre printers and publs. Delhi)

DSCIII. Research Methodology and Introductory Biostatistics

Credits: 3+2

Unit - I

Introduction and role of statistics in MAPs research. Sampling theory and experimental designs, screening designs, evaluation and choice of experimental designs. Replication, randomization and complete randomized design. Genetic designs, Latin square and split plot.

Unit – II

Classification and summarization of data. Diagrams and graphs. Measurement of central tendency and measures of dispersion. Testing of hypothesis including mean, variance and proportion. Test based on χ^2 distribution including ANOVA. Non-parametric tests. Correlation and regression analysis.

Unit – III

Introduction and history of computer and computer network. Concepts of operating system, control structures, function and subroutines. Concepts of files; program files and data files etc. Computer applications in plant sciences.

Practicals:

Setting up of an experiment, collection of data, analysis of data using different statistical procedures. Familiarization with different statistical software packages.

Suggested Readings:

1. Biostatics a guide to design analysis and discovery by L. Farthofer.
2. Principles of biostatics by Pa Marcello.
3. Statistical Methods and Concepts by M.N. Das, Wiley Eastern Ltd. New Delhi.
4. Statistical Methods for agricultural workers by V.G. Panse, ICAR.
5. Introductory practical biostatics by M. Mishra and M.K. Mishra.
6. Practical in statistics by Sharma.
7. Statistical methods in applied biology by Nayak.
8. Basic statistics by B.L. Agarwal

DSC Practical: Research Methodology and Scientific Writing Credit 3

Unit 1: Practical Use of Software & Tools in Research

Literature Review and Research Framing: Searching literature using Scopus, Web of Science, Google Scholar, Identifying gaps and formulating research problems, Hands-on framing of objectives, hypotheses, and research questions. **Reference Management:** Installing and using Zotero/Mendeley/EndNote, Creating and organizing libraries, Inserting citations and auto-generating bibliography in MS Word.

Unit 2:

Designing questionnaires/interview guides (Google Forms, KoboToolbox). Statistical Analysis Basics: Introduction to **SPSS, R, Excel**, Data entry, descriptive stats, cross-tabulation, Visualization: Graphs, tables, charts.

Unit 2: Scientific Writing, Thesis, and Proposal Preparation

Research Proposal Drafting: Step-by-step practical: Title, background, objectives, methodology, Budgeting. Thesis Writing & Formatting: Thesis template formatting, Section-wise formatting: TOC, page breaks, captioning, references. Abstract and Conclusion Writing, writing exercise: Objectives, findings, and conclusion from given data. Plagiarism Check & Writing Improvement Tools: Using Turnitin or open plagiarism checkers, Sentence clarity: Grammarly, Hemingway, Quillbot. Referencing Practice: Practice applying APA, MLA, Chicago referencing styles. Mini Research Proposal/Synopsis Submission

Unit 4: Scientific Publishing and Communication

Journal Targeting and Manuscript Preparation: Identifying suitable journals, Writing Title, Abstract, Keywords from given topic, Ethics, Peer Review, and Submission Simulation: COPE guidelines, authorship, plagiarism, predatory journals, Practice responding to peer review using sample reviewer comments. Final Submission & Peer Review- Submission simulation on journal platforms (dummy accounts), Peer-review of each other's mini research proposals

DSE1. Medicinal plants case studies. Credit 4+2

Origin, distribution, phenology, cultivation prospects including climate & soil requirement, propagation, manures & fertilizers, irrigation, maturity, harvesting, yield and post-harvest handling. (Any one of the following sections).

- A)** Alpine species: *Aconitum balfourii*, *A. heterophyllum*, *Picrorrhiza kurroa*, *Nardostachys jatamansi*, *Rheum emodi*, *Podophyllum hexandrum*, *Coptis teeta* and *Panax species*.

OR

- B)** Temperate species: *Valeriana wallichii*, *Zanthoxylum armatum*, *Allium stracheyi*, *Asparagus racemosus*, *Hedychium spicatum*, *Saussurea costus*, *Valeriana wallichii* and *Swertia chirayita* and *Paris polyphylla*).

OR

- C)** Tropical species: *Withania somnifera*, *Rauvolfia serpentina*, *Catharanthus roseus*, *Azadirachta indica*, *Chlorophytum borivillanum*, *Tinospora cordifolia*, *Dioscorea deltoidea*, *Coleus barbatulus*, *Emblica officinalis* and *Piper longum*).

Practical: (Common to All Groups)

Identification and documentation of selected species, Study of origin, distribution, and phenology, Assessment of climate and soil requirements. Propagation techniques, Manure and fertilizer application, Irrigation management. Maturity and harvesting indicators. Post-harvest handling

DSE2. Organic and Protected Cultivation

Credit 4+2

UNIT I

Organic Cultivation – definition, synonyms and misnomers, principles, methods, merits and demerits. Organic farming systems, components of organic farming systems, different organic inputs and their role in organic production, role of biofertilizers, biodynamics and the recent developments.

UNIT II

Effective Microorganisms (EM) technology and its impact in organic cultivation, indigenous practices of organic farming, FYM, composting, mulching, sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, organic cultivation in quality improvement. Good Agriculture Practices (GAP) - Principles and management. Constraints in certification, organic production and export, IFOAM and global scenario of organic movement, post-harvest management of organic produce.

UNIT III

Importance and scope of protected cultivation of MAPs; principles used in protected cultivation, energy management, low cost structures; training methods; engineering aspects. Greenhouse – World scenario, Indian situation: present and future, Environmental factors and their effects on plant growth. Polyhouse, Shade-net house, Polytunnel and Polypit.

Practicals:

Method of preparation of compost, vermicomposting, biocomposting, biofertilizers, soil solarization, bio pesticides, green manuring, mycorrhizae and their application in organic crop production. Weed management in organic cultivation. Visit to organic fields and marketing centers.

Suggested readings:

1. Organic Farming-Theory and Practise by Palaniappan & Annadurai, Scientific Publ. (2008).
2. Green House Operation and Management by Pant V. Nelson, Bali Publ. (1991).
3. Management of Horticultural Crops. Parts I, II, by T. Pradeepkumar, B. Suma, Jyothibhaskar & K.N. Satheesan, New India Publ. Agency (2007).
4. Organic Farming by N. Lampkin & Ipswich, Farming Press, London (1990).
5. The Economics of Organic Farming – An International Perspective by N.H. Lampkin & S. Padel, CABI (1992).
6. Basics of Horticulture by K.V. Peter (Ed.) New India Publ. Agency, New Delhi (2008).
7. Soil Microorganism and Plant Growth by S. Rao, Oxford & IBH (1977).
8. Green House Engineering by R.A. Aldrich & J.W. Bartok, NRAES, Riley, Robb Hall, Cornell University, Ithaca, New York-21 (1994).

DSE3. Marketing of MAPs Credit 4+2

Unit - I

Overview of the global MAPs market: Trends and growth drivers in MAPs industry, Trends and growth drivers in MAPs industry, Value Chain Analysis of MAPs: Components of the MAPs value chain, Role of different stakeholders (farmers, traders, processors, etc.), Value addition opportunities along the MAPs value chain. Market Research and Analysis: Market research methods and techniques: Data collection and analysis for MAPs market, Market segmentation and targeting strategies, Marketing Strategies for MAPs, Product positioning and differentiation, Pricing strategies for MAP products, Promotional strategies (advertising, public relations, etc.)

Unit ii

Branding and Packaging: Importance of branding in MAP marketing, Packaging design and materials for MAP products, Labeling requirements and regulations. Distribution Channels and Logistics Management: Types of distribution channels for MAPs, Selection of distribution partners (wholesalers, retailers, etc.), Logistics management and transportation considerations. Regulatory Frameworks and Quality Standards: Regulatory requirements for MAP cultivation, processing, and marketing, Quality standards and certifications (GMP, Organic, etc.), Compliance with international regulations (CITES, Convention on Biological Diversity, etc.)

Unit III

Export-Import Procedures for MAPs: Export procedures and documentation, Import regulations and customs clearance, Market access barriers and trade agreements affecting MAPs. Entrepreneurship and start up opportunities in MAPs (Licensing and manufacturing). Financing Options for MAPs. Entrepreneurs Sources of funding for MAPs startups (grants, loans, equity financing, etc.) Accessing government support programs and incentives, Pitching to investors and securing funding. Legal and Regulatory Considerations.

Unit iv

NMPB-AYUSH, Voluntary Certification Scheme for Medicinal Plant Produce, Subsidies from Indian Government, Buyback Agreement and Contract farming with AYUSH and other Companies. Subsidies from Indian Government, Buyback Agreement and Contract farming with AYUSH and other Companies. Quality control, Standards and Regulations of traditional Plant Drugs WHO and ICH Guidelines. AYUSH, CDSCO and FSSAI Guidelines. Value added products: AYUSH Products, food, nutraceuticals, cosmetics and agrochemicals.

Practicals: Practical work on the selected species as per the course contents.

Suggested readings

1. "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries
2. "Startup: A Silicon Valley Adventure" by Jerry Kaplan
3. "Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers" by Alexander Osterwalder and Yves Pigneur
4. Cultivation and Utilization of Medicinal and Aromatic Crops by C. Atal & V. Kapoor, CSIR (1992).
5. Cultivation and Utilization of Aromatic Plants by C.K. Atal & B.M. Kapur, CSIR, RRL, Jammu (1982).
6. Production Technology of Medicinal and Aromatic Crops by A.A. Farooqi, M.M. Khan & M. Vasundhara, Natural Remedies Pvt. Ltd. (2001)..

Community engagement/ Field project in place of the Practical of elective Course for 2Credits

Fourth Semester for 2-year P.G. program

DSC1. Herbal Chemistry

Credit 3+2

Unit- I

Plant acids-sources and functions, sugar alcohols, sugar acids-alonic acid, uronic acid, aldaric acid, sugar amines-Glucosamine and Galactosamine-sources and functions, sources and function of medicinal polysaccharides :dextrins, inulin, gums and mucilages, Peptides and lectins of medicinal importance, glycosides-sources and functions, anthraquinones, saponins.

Unit-II

Plant defence, molecules involved in defence mechanisms. Major plant secondary metabolites and outline study of: Alkaloids-nature, classification, distribution, biosynthesis and functions, Phenolics-nature, classification, distribution, biosynthesis and functions, Terpenoids-nature, classification, distribution, biosynthesis and functions.

Unit II:

Basic pathways of synthesis of secondary metabolites and production of phyto-pharmaceuticals such as glycosides, alkaloids and isoprenoid compounds. Biogenesis of medicinally important glycosides and alkaloids - Anthraquinone glycosidal drugs, saponin glycosidal drugs, cyanogenetic glycosidal drugs, coumarins and furanocoumarin glycosidal drugs. Isoquinoline alkaloidal, tropane steroidal and terpenoid alkaloidal drugs etc.

Unit III:

The physiological roles of secondary metabolites in relation to Plant-vertebrate interaction; Plant-insect interaction; Plant – plant interaction; plant-microorganisms interaction. Turn over and degradation of secondary metabolites - The concept of turn over of secondary metabolites.

Unit IV:

Accumulation of secondary products and the differentiation of storage spaces. Secondary metabolites and plant systematic- The relationship of chemical and botanical data. Introduction to amino acids, enzymes, terpenoids (volatile oils and resins) and plant hormones. Factors influencing production of secondary metabolites in plants. Cellular localization of secondary metabolites, modern techniques to study secondary metabolites, metabolomics and metabolic control.

Practicals:

Primary Metabolites and Medicinal Derivatives: Qualitative tests for plant acids (e.g., citric, oxalic, and malic acids). Identification of sugar alcohols, sugar acids and amines, Extraction and estimation of various secondary metabolites. Identification of glycosides and saponins. Study of plant tissues rich in alkaloids, phenolics, and terpenoids (thin section microscopy). Simple experiments demonstrating allelopathy. Microscopy of secretory tissues (laticifers, oil glands, resin ducts). Preparation of plant-based crude extracts for metabolomic profiling.

Suggested Readings:

1. Medicinal Chemistry by G.R. Chatwal (1998).
2. Medicinal Chemistry: A Molecular & Biochemical Approach by Mogarthey and Donald (2006).
3. The Biochemistry of Plants by EE Conn.
4. Plant Biochemistry by Hans-Walterheldt.
5. Medicinal Chemistry Laboratory Manual by Dickson (1998).
6. Introduction to Medicinal Chemistry; How Drugs Act & Why by Gringauz (1997).
7. Biochemistry Vol 6 by Freeman.

Text Books /Essential Readings:

1. The Biochemistry of Plants by EE Conn.
2. Plant Biochemistry by Hans-Walterheldt.
3. Medicinal Chemistry by GR Chatwal. (1998).

Suggested Readings:

1. Medicinal Chemistry: A Molecular & Biochemical Approach by Mogarthey and Donald (2006).
2. Medicinal Chemistry Laboratory Manual by Dickson, (1998).
3. Introduction to Medicinal Chemistry; How Drugs Act & Why by Gringauz, (1997).
4. Biochemistry Vol 6 by Freeman

DSC II. Propagation & Nursery Management

Credits: 3+2

Unit I

Propagation: Need and potentialities for plant multiplication, sexual and asexual methods of propagation, apomixes – mono-embryony, polyembryony, chimera & bud sport. Seed dormancy (scarification & stratification) internal and external factors, nursery techniques.

Unit II

Propagation Structures including mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds, poly-houses, nursery (tools and implements) and growing media.

Unit III

Propagation methods: Use of growth regulators in seed and vegetative propagation, methods and techniques of cutting, layering, grafting and budding physiological & bio chemical basis of rooting, factors influencing rooting of cuttings and layering, graft incompatibility. Micrografting.

Unit IV

Techniques for *in vitro* propagation, factor affecting tissue culture, culture room, hardening, hardening of plants in nurseries, approaches in micro propagation of banana, strawberry, papaya.

Unit V

Propagation methods of some commercially important medicinal plants i.e. Neem, Sarpagandha, Harar, Bahera, Amla Asparagus, Zanthoxylum and Tejpat.

Practical

Sexual vs. asexual propagation through seed and vegetative parts. Identification and demonstration of apomixis, monoembryony, polyembryony (with seed samples). Demonstration of seed dormancy-breaking methods: scarification (mechanical and acid), stratification (cold treatment). Preparation of nursery beds, sowing, and transplanting techniques. Demonstration of propagation tools and implements (grafting knife, budding tools, secateurs). Practical on cutting techniques (softwood, semi-hardwood, hardwood) and treatment with rooting hormones (IBA, NAA). Demonstration and practice of layering techniques (mound, serpentine, air layering). Practice of grafting (cleft, veneer, whip) and budding (T-budding, patch budding). In Vitro Propagation and Hardening. Propagation techniques for Commercially Important Medicinal Plants.

Text Books/ Essential readings:

1. Hartmann, H.T & Kester, D.E (1989). *Plant Propagation – Principles and Practices*. Prentice Hall of India.
2. Bose, T.K, Mitra, S.K& Sadhu, M.K(1991).*Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash.
3. Peter, K.V(Ed.)(2008). *Basics of Horticulture*. New India Publ. Agency.

Suggested Readings

1. Singh, S,P (1989) *Mist Propagation*. Metropolitan Book Co.
2. Rajan, S & Baby, L.M (2007).*Propagation of Horticultural Crops*. New India Publ. Agency.
3. Radha, T & Mathew, L(2007). *Fruit Crops*. New India Publ. Agency.
4. Dey, Kalyan Kumar (1992). *An Introduction to Plant Tissue Culture*, New Central Book Agency, 8/1 Chintamonni Das Lane, Calcutta-700009.

DSCIII. Bioresources Management

Credits: 3 +2

Unit I:

Introduction to Bioresources Management: Definition and scope of bioresources
Importance of bioresources in ecological, economic, and social contexts. Challenges and opportunities in bioresource management. Biodiversity Conservation
Concepts and theories of biodiversity, threats to biodiversity loss and monitoring of biodiversity.
Status and strategies for bioresource management, Sustainable exploitation and development.

Unit II:

Resources management including forest, grassland, cropland, Wetlands and estuary bioresource management, Microbial resource management, Wildlife management. Energy Conservation-efficiency in production, transportation and utilization of energy. Future sources of energy with major emphasis on biodiesel.

Unit III:

Important legislations in relation to Plant resources: Wildlife Protection Act 1972, Forest Conservation Act 1981. Etc. Environmental impact statement (EIS), Environmental management plan (EMP) and Environmental clearance for establishing industry.

Unit IV

Principles of conservation, extinction and threat assessment, environmental status of plants based on

International Strategies for conservation including organizations viz., WWF, IUCN and conventions i.e. CBD, GSPC ; Biodiversity Bill India, 2002. Policy and Governance in Bioresources Management.

Practical

Preparation of a report on local bioresources and their ecological, economic, and social significance. Mapping and listing of local biodiversity (species richness and endemism). Field methods for biodiversity monitoring (quadrat sampling, transects). Calculation of biodiversity indices (Simpson's, Shannon-Wiener Index). Case study analysis on sustainable exploitation and bioresource-based livelihoods. Visit to or case study on an ecosystem with biodiversity importance. Case study presentation on the Wildlife Protection Act 1972 or Forest Conservation Act 1981. Preparation of a mock Environmental Impact Statement (EIS) for a hypothetical development project. Drafting an Environmental Management Plan (EMP) for a local industry or tourism site. Documentation of rare, endangered, or threatened plants in a selected area.

Essential readings:

1. An Advanced text book on Biodiversity: Principles and Practices (2004); Oxford and IBH Publ. Co. Pvt. Ltd.

Suggested Readings/ Reference:

1. Ecology and Environment, P.D. Sharma, Rastogi Publications
2. Environmental Studies, R. Rajagopalan, Oxford University Press
3. Environmental Impact Analysis: A new dimension in decision making, 2nd edition, R.K. Jain, L.V. Urban and G.S. Stacy, published by Van Nostrand Reinhold Company
4. Biogeography, Robinson, H. ELBS, London, 1978
5. Heywood, V.H. and Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge University Press.
6. Handbook of Environmental Law in India (2009). B. Sahasranaman, Oxford University Press.
7. Environmental Law and Policy in India (2005). Tiwari, A.K., Saujanya Books, N. Delhi.
8. Environmental and Pollution Law in India (2005), Justice T.S. Doabia..

DSC Practical: Techniques in Herbal Product Development and Standardization Credit 3

Unit 1

Drying Techniques: Shade drying, solar drying, hot air oven, Moisture content determination, Extraction Techniques- Preparation of Extracts: Decoction, infusion, maceration etc. Steam Distillation of Essential Oils: Working of distillation unit Oil recovery and yield analysis. Solvent Extraction Techniques: Soxhlet setup demonstration, Essential oil vs. oleoresin extraction.

Unit 2

Herbal Formulations (Nutraceuticals, Cosmetics, and Pharmaceuticals)- Herbal Teas and Infusions: Formulation with dried herbs, Taste/aroma testing, Herbal Tablets, Capsules & Powders: Granulation, drying, compression (demo) Filler/binder use. Herbal Creams and Ointments: Base preparation, Mixing and emulsion stability, Cleansers, Shampoos, soaps and other herbal formulations: pH balancing, preservatives etc.

Unit 3

Essential Oil Blending and Aromatherapy Products: Fragrance mixing, Carrier oil preparation, Dhoop and Incense Sticks, Aroma Candles and Diffusers, Home and Lifestyle Aroma Products, Bath and Body aroma products.

Unit 4

Grading, Packaging, Labelling and Compliance Basics Quality Control and Standardization- Adulteration Detection and Sensory Evaluation: Visual, olfactory, and organoleptic tests, Simple Phytochemical Screening : Alkaloids, flavonoids, phenols etc, Microbial Testing and Shelf-life Studies- Sample plating, contamination check (intro only)

DSE1.Dissertation/ Project workCredit: 6

Each student will be assigned a topic for dissertation/ project work that will involve field or laboratory study on a particular medicinal or aromatic plant species. It will be supervised by a faculty member. The course will have to be completed within the IV Semester. There will be two mid term assessment of the dissertation work. Students will prepare project report and submit it before final examination. After primary evaluation by supervisor, students will present project work in the seminar before external examiner and committee of the faculty members.

Assessment of Marks for End Semester Exam, 60 marks:

Project Report:	35	
Project Seminar:		15
Viva voce:	10	

DSE2. Processing Technology of Aromatic Plants**Credits: 4+2****Unit I:**

Post Harvest Technology of aromatic plants: Harvesting, Drying, Storage and Size Reduction. Case studies-post-harvest technology of selected aromatic plants.

Unit II:

Sources of natural essential oils. Methods of producing essential oils. Types of volatile extracts-Concretes, Absolutes, Resinoids and Pomades. Extraction Techniques: Extraction with hydrocarbon solvents, Extraction with Non-Volatile Solvents; Maceration and Enflourage. Modern extraction techniques-Supercritical fluid extraction (SFE), Microwave-Assisted Hydrodistillation (MAHD), Ultrasound-assisted extraction (UAE), Solvent-free microwave extraction (SFME), Microwave hydro diffusion and gravity (MHG).

Unit III:

Distillation Techniques with special reference to Conventional Rural Distillation; Designing of Distillation Unit viz., Furnace, Distillation Tank and its Advantages; Distillation with Cohobation-advantages, Boiler, Condenser and Oil Separator.

Unit IV:

Hydrodistillation: Water distillation, Water and Steam distillation, Steam distillation and Hydrodiffusion; Volatility and Solubility of Essential oil; Disadvantages of Hydrodistillation and its \safety measures. CIMAP Model-Details and specific advantages.

Unit V:

Factors effecting yield and quality of Essential oil(s). Different essential oils and their chemical constituents along with commercial uses - Citronella oil, Geranium oil, Lemon grass oil, Ajowain oil, Davana oil, Mentha oil and Citrus oil; Value Addition of Aromatic Plant(s) and their Bioprospects.

Practical

Practical demonstration of optimal harvesting stages for selected aromatic crops, Drying methods: shade drying vs. mechanical drying and effect on aroma and oil yield. Study of storage techniques and conditions affecting essential oil stability. Size reduction and preparation of plant material for extraction (grinding, chopping). Case studies: post-harvest handling protocols of at least two aromatic plants. Identification of sources of natural essential oils from fresh or dried Layout and working of conventional rural distillation units. Practice session on steam distillation using *Mentha* or *Citronella*

plant material. Comparative analysis of essential oil yield and quality from different drying/extraction methods. Sensory and chemical evaluation (odor profile, refractive index, solubility in alcohol).

Text Books /Essential Readings:

1. Aromatic and Medicinal Plants: Yielding Essential oil for Pharmaceutical Perfumery and Cosmetic Industry and Trade by Shiva, M.P. (2002).
2. Post Harvest Technology of Fruits and Vegetables, Handling, Processing, Fermentation and Waste Management, Vol I & II- By Verma and Joshi, (2000).

Suggested Readings:

1. Plant Constituents and their Mechanism of Action as Pesticide by A. C. Shukla (2012), Lambert Academic Publishing, Germany (ISBN 978-3-659-13267-4).
2. Post harvest Technology of Flowers and Ornamental Plants- By Salunke et al.

DSE 3 . Ethno-botany

Credits: 4+2

Unit I:

Ethno-botany: Introduction, concept, scope and objectives; Ethno-botany as an interdisciplinary science. The relevance of ethno-botany in the present context; .Ethnic groups and Ethnobotany: Major and minor ethnic groups or Tribals of India, and their life styles. Forest Vs. ethnic groups; Plants in Tribal life with reference to Magico-religious rituals (Shamanistic) and social customs. Sacred groves. Challenges and future prospects of ethnoflora, ethnic groups or tribes in current changing scenario.

Unit II:

World centers of primary diversity of domesticated plants: Vavilov's centres of origin; The Indo-Burmese centre; plant introductions and secondary centers. Origin, evolution, botany, cultivation and uses of (i) Food, forage and fodder crops, (ii) fibre crops, (iii) medicinal and aromatic plants, and (iv) vegetable oil-yielding crops.

Unit III:

Methodology of Ethno-botanical studies: a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places) Protocols; Plants Vs. Tribal Life: a) Food plants and Food cycles b) Intoxicants and Beverages c) Ropes and Bindings materials d) Resins and oils. ; Important fire wood, timber yielding and non-wood forest products (NWFPs) such as bamboos and rattan, gums, tannins and dyes and fruits with reference to NE, India and Mizoram. Statistical methods in ethnobotany, i.e. Sampling methods, questionnaires, statistical analysis of ethnobotanical data including ethnobotanyR package.

Unit IV:

Plants and tribal medicines with reference to Uttarakhand: Significance of the some important plants of the region viz., *Aconitum*, *Podophyllum*, *Picrorhiza*, *Valeriana*, *Cinnamomum* etc in Tribal medical practices (along with a brief note on their habitat and morphology); .Role of ethno-botany in modern Medicine with some examples. Different aspects of ethnobotany in Uttarakhand i.e. Ethnoecology, ethnozoology, ethnomedicine etc.

Unit V:

Medico-ethno-botanical sources in India with special reference to Uttarakhand; Role of ethnic groups on surrounding environment. Crop Genetic sources. Endangered taxa and forest management (participatory forest management). Ethno-botany and legal aspects. Ethno-botany as a tool to protect interests of ethnic groups.

Practical work

Collection of plants and herbarium methods, Statistical methods in ethnobotany and data analysis using excel, and R; Demo of Group discussion and Interview.

Text Books/ Essential Readings:

1. Cotton C.M. 1997. Ethnobotany : Principles and Applications. John Wiley and sons – [Chichester](#)

Suggested Readings:

1. S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
2. S.K. Jain (ed.) Glimpses of Indian. Ethnobotny, Oxford and I B H, [New Delhi](#) – 1981
3. Beatrice, H.K. 1975. Ethnobotany of Hawaiians
4. Journal of Ethnobotany, Lucknow
5. S.K. Jain (ed.) 1989. Methods and Approaches in Ethnobotany. Society of Ethnobotanists, Lucknow, India.
6. S.K. Jain, 1990. Contributions of Indian Ethnobotny. Scientific Publishers, Jodhpur.
7. Rajiv K. Sinha – Ethnobotany The Renaissance of Traditional Herbal Medicine – INA – SHREE Publishers, [Jaipur](#)-1996
8. D.C. Pal S.K. Jain 1998. Tribal Medicine.