HNB Garhwal University, Srinagar Garhwal
High Altitude Plant Physiology Research Centre

M.Sc. (Medicinal & Aromatic Plants)

Syllabus

I Semester

CMAP-101. Introduction to Medicinal and Aromatic plants Credits: 3+1

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 Practices (GAP). 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*, *Adhatoda vasica*, *Abrus precatorius* Aloe vera, Phyllanthus amarus, Stevia rebaudiana, Belladona 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, davana, 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, curryleaf and saffron.

Practicals: Sample collection of the selected species as per the course content.

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).

CMAP-102. Traditional System of Medicine & Intellectual Property Rights Credits: 2+1

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: Theme Presentation

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 Mahendrpal Singh, Dehradun (2004).

CMAP-103. Growth and Development Credits: 3+1

Unit - I

Growth and development of MAP crops; Phases of growth; Factors affecting growth and development; Juvenile and reproductive phases; Physiology of flowering; Photoperiodism; Vernalisation; Maturation and ripening; respiratory climacteric and non-climacteric; physiology and biochemistry of ripening. Senescence; Tuberization, formation of bulbs, rhizomes, corms etc.

Unit - II

Plant propagation; Different methods of propagation; Sexual and Asexual modes of propagation; Seed production; Seed germination and dormancy; Vegetative propagation-Cutting, budding, grafting and layering. Micro-propagation.

Unit - III

Systems of cultivation; High density cultivation; Different cropping systems in MAPs; Production and training in MAPs.

Unit – IV

Biofertilizers, vermicompost and organic farming; Role of plant growth regulators with special reference to MAPs; Integrated nutrient management; Weed management; Irrigation systems.

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

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. Hudsont: Plant propagation principles and practices

CMAP-104. MAPs production-I Credits: 3+1

Unit - I

Aconites: origin and distribution, compositions and uses, species and cultivars. Propagation and planting of Aconites. Soil, climate, irrigation and nutrition requirement of Aconites. Maturity and harvesting. Pests and diseases of Aconites.

Rhubarb: origin, sex expression, propagation and planting. Cultivation techniques including soil and climatic requirements, manures and fertilizers, irrigation, harvesting and post harvest handling, extraction.

Unit - II

Origin and distribution of Sarpgandha, flowering and fruiting. Cultivation practices including climate & soil, propagation, manures & fertilizers, irrigation, maturity and harvesting, post-harvest handling.

Origin, distribution and importance of *Asparagus*. flowering and fruiting. Cultivation practices including climate & soil, propagation and planting, nutrition and irrigation requirement, maturity and harvesting of *Asparagus*.

Dioscorea: Origin, importance, Cultivation including soil & climate, propagation, flowering, maturity, ripening, harvesting and storage.

Unit - III

Gloriosa superba: origin, distribution and importance. Soil & climate, propagation & planting, irrigation, flowering, maturity and harvest. =0Origin, importance, ecological races of *Catharanthus roseus*. Cultivation including soil & climate, propagation, flowering, maturity, ripening and storage.

Ashwagandha: origin and importance. Cultivation practices including climate, soil, nutrition and water requirements; propagation and rootstocks, maturity and harvesting.

Andrographis paniculata: Origin, uses, important cultivars. Cultivation practices including climate, soil, irrigation and nutritional requirements; propagation and planting; maturity and harvesting.

Unit - IV

Piper: origin and distribution, important cultivars, propagation. Cultivation requirements including climate and soil, manuring and irrigation, maturity, harvesting and yield. Important diseases and pests of piper.

Pattharchoor: Origin, uses, important cultivars. Cultivation practices including climate, soil, irrigation and nutritional requirements; propagation and planting; maturity and harvesting.

Ocimum: origin, sex expression, propagation and planting. Cultivation techniques including soil and climatic requirements, manures and fertilizers, irrigation, harvesting and post harvest handling.

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

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).

CMAP-105. Plant Systematics and Conservation Credits: 2+1

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.

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).

II Semester

CMAP-201. MAP Production-II Credits: 3+1

Unit - I

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 garlic, jamboo etc.

Unit - II

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; Processing, quality evaluation and grading of *Picrorhiza kurrooa*.
Pseudogenseng: origin, sex expression, propagation and planting. Cultivation techniques including soil and climatic requirements, manures and fertilizers, irrigation, harvesting and post harvest handling.

Unit - III

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, processing of *Chlorophytum.*

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.

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

Suggested readings

1. Commercially important medicinal and aromatic plants of Himachal Pradesh by P.B. Singh (1999).
2. Agrotechniquies 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)..

CMAP-202. Quality control and Phytochemical methods Credits: 2+1

Unit-I

Drug examination; Macroscopic and Microscopic evaluation; Moisture content; Microbial nfestation; 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.

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.

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).

CMAP-203. Introductory Herbal Biochemistry Credits: 2+1

Unit-I

Outline study of major metabolic pathways –cellular localization of secondary metabolites, modern techniques to study secondary metabolites, metabolomics and metabolic control.

Unit-II

Plant acids-sources and functions, sugar alcohols, sugar acids-aldonic 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-III

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.
Factors influencing production of secondary metabolites.

Practicals:

Estimation of secondary metabolites -alkaloids, phenolics, and terpenoids by different methods.

Suggested Readings:

1. Medicinal Chemistry by G.R. Chatwal (1998).
2. Medicinal Chemistry: A Molecular & Biochemical Approach by Mogardey 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.

CMAP-204. Pharmacognosy Credits:3+1

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, neutraceuticals 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 *Gymnema sylvestre, Azadirahcta*

indica, Adhatoda vasica, Asparagus racemosus, Commiphora mukul, Podophyllum hexandrum, Ocimum sanctum, Shankapushpi and Tylophora asthamatica.

Practicals:
Different methods of drug identification and evaluation, biological testing of herbal drugs. Visit to practioner 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. Lalchman & J.B. Schwarts, (Vol I, II, III) (1989).
7. Evaluation of Phyto-pharmaceuticals by Turner.
8. Textbook of Pharmacognosy by Shah and Qadry.

CMAP-205. Post-Harvest Technology Credits: 3+1

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: Theme Presentation.

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).

III semester

CMAP-301. Introductory Herbal Biotechnology Credits: 2+1

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.

CMAP-302. Integrated Plant Protection Credits: 2+1

Unit-I

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

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.

Practicals: Collection of the pests and weeds.

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)

CMAP-303. Research Methodology and Introductory Biostatistics Credits: 2+1

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 x^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

ELECTIVES

EMAP-304. Medicinal plants case studies. Credits: 2+1

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 kurrooa, 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 wallichi* and *Swertia chirayita and Paris polyphylla.*

OR

C) Tropical species: *Withania somnifera, Rauvolfia serpentina, Catharanthus roseus, Azadirahcta indica, Chlorophytum borivilianum, Tinospora cordifolia, Dioscorea deltoidea, Coleus barbatus, Emblica officinalis and Piper longum.*

EMAP-305. Any one of the following sections Credits: 2+1

A). Organic and Protected Cultivation

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).

OR

B). Introductory Pharmacology

Unit-I

Definitions, scope and general principles of pharmacology. Nature and sources of drugs, drug nomenclature, essential drug (medicine) concept. Detail discussion, merits and demerits of various routes of drug administration. Pharmacology of chemotherapeutic and antimicrobial agents.

Unit-II

Physiochemical factors and processes in transfer of drug across the biological membranes. Drug absorption, Bio-availability, factors affecting drug absorption and bio-availability. Adverse drug reactions and drug interactions.

Unit-III

Bioassays: General methods and bioassays of different drugs. Basic concept of toxicity, different tests, teratogenicity and carcinogenicity, itrogenic diseases, tolerance, habituation and addiction.

Suggested Readings:

1. The Theory & Practices of Industrial Pharmacy by L. Lachman, 2nd *eds*, (1976).
2. Pharmaceutical Practice by M.E. Aulton.
3. General Pharmacy by Cooper and Gunn.
4. Text book of Pharmacology by Barar.
5. Pharmacopeia of India 4th *eds*, (1996).
6. Physical Pharmacy by Martin.

7. Experimental Pharmacology by M.N. Ghosh.
8. Screening Method in Pharmacology: A Textbook of Pharmaceutical Analysis by Conors.

OR

C). MAP Bioresource Management

Unit I

Importance of resource management: Genetic biodiversity of medicinal plants, Conservation networks, Global initiatives on medicinal plants conservation and development, World history on usage of medicinal plants, Preference to natural products, Advanced research in biomedicines, Nutraceuticals and natural drugs.

Unit II

MAPS: Identification, Inventory, Mapping, Population assessment, Sustainable collection, Conservation, Cultivation, Regeneration, Intercropping, Crop rotation, Indigenous knowledge of farming systems, Yield, Trade, Products, Certification, Documentation.Quantification: frequency, relative frequency, abundance, density, relative density and yield.

Unit III

Threats: RET (Rare, Endangered and Threatened) medicinal and aromatic plants of Indian Himalaya. Present status and future prospects, species, economic parts and their uses in different diseases. IUCN, Convention on Biological Diversity, Convention on International Trade in Endangered Species of Wild Fauna and Flora, World Health Organization, Legal and Ethical requirements (Laws, regulations and administrative requirements), Benefit Sharing, Financial viability, Traceability.

Theme Presentation Seminar on Assigned Topic

Suggested Readings:

1. An Advanced text book on Biodiversity: Principles and Practices; Oxford and IBH Publ. Co. Pvt. Ltd (2004).
2. Ecology and Environment by P.D. Sharma, Rastogi Publications.
3. Environmental Studies by R. Rajagopalan, Oxford University Press.
4. Environmental Impact Analysis: A new dimension in decision making, second edition by R.K. Jain, L.V. Urban and G.S. Stacy, Van Nostrand Reinhold Company.
5. Pollution Control and Conservation by M. Kovacs (ed), Ellis Horwood Ltd., Budapest (1985).
6. Global Biodiversity Assessment by V.H. Heywood and R.T. Watson, Cambridge University Press (1995).
7. Handbook of Environmental Law in India by B. Sahasranaman, Oxford University Press (2009).
8. Environmental and Pollution Law in India by Justice T.S. Doabia (2005).

CMAP-306. Assignment based seminar Credits: 3

Each student will be given an assignment involving either field or laboratory experiment or subject review.

IV Semester

EMAP- 401. Core Course: Dissertation/ Project work Credits: 9

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

ELECTIVES (Any three of the following)

EMAP- 402. Herbal Chemistry Credits: 03

Unit I:

Biosynthesis of carbohydrates, lipids, volatile oils and resins. Types and classification of carbohydrates and lipids and their uses as phytopharmaceuticals.

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.

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 Mogardey 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

EMAP 403. Propagation & Nursery Management Credits: 03.

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, Sarpgandha, Harar, Bahera, Amla Asparagus, Zanthoxylum and Tejpat.

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.

EMAP- 404. Bioresources Management Credits: 03

Unit I:

Biogeographical zones of India, major biomes of the world, Vegetation mapping 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.

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..

EMAP 405. Processing Technology of Aromatic Plants Credits: 03

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 Enfluarage. 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.

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.

EMAP 406. Ethno-botany Credits: 03

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 Hawwaians
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.

SELF STUDY COURSES

Students have to select one of the following courses for self study. This course will not be taught in the department and students have to go for self study in this course as per the syllabus prescribed for the course. Sessional and final exam in this course will be conducted by the department.

SMAP 407A. Production Technology of Aromatic Plants Credits:03

Unit - I

Scope of aromatic plants in global trade, Global Scenario of aromatic plants production. Area under aromatic pants and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices.

Unit - II

Growing environment, open cultivation, protected cultivation, soil requirements, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth of aromatic plants. Soil and climate requirements, field preparation for important aromatic plants.

Unit - III

Aromatic plants production – water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies.

Unit - IV

Aromatic plants standards and grades, harvest indices, harvesting techniques, post-harvest handling, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

Crops:

Citronellal, Damask rose, Khus grass, Large cardamom, Lavander, Lemon grass, Holy basil, Patchouli, Geranium, Lemon grass, Davana, Mentha, Jatamansi and Rosemary.

Suggested Readings

1. Arora JS. 2006. Introductory Ornamental horticulture. Kalyani.
2. Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
3. Bose TK & Yadav LP. 1989. Commercial Flowers. Naya Prokash.
4. Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Naya Prokash.
5. Chadha KL & Chaudhury B. 1992. Ornamental Horticulture in India. ICAR.
6. Chadha KL. 1995. Advances in Horticulture. Vol. XII. Malhotra Publ. House.
7. Lauria A & Ries VH. 2001. Floriculture – Fundamentals and Practices. Agrobios.
8. Prasad S & Kumar U. 2003. Commercial Floriculture. Agrobios.
9. Randhawa GS & Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
10. Sheela VL. 2007. Flowers in Trade. New India Publ. Agency.

SMAP – 407B: Cultivation & Trade of MAPs Credits:03

Unit - I

History, present status and future prospects of MAPs cultivation in India. Development of agro-techniques of MAPs – including domestication, improved varieties, cultivation packages and economical viability. Selection of elite germplasm for domestication. Appropriate harvesting techniques and season.

Unit - II

Methods of propagation. Sexual methods - Seed physiology including seed dormancy, types of seeds, seed storage, viability, germination and seed vigor. Asexual propagation- including apomixes, vivipary & vegetative propagation methods for MAPs. Factors affecting MAPs cultivation including topography, climatic conditions, soil and soil fertility and practices of cultivation.

Unit – III

Cultivation practices for temperate medicinal plants – Aconites, *Andrographis paniculata*, *Asperagus racemosus, Coleus barbatus*, *Chlorophytum tuberosum, Gloriosa superva*, *Catheranthus roseus, Dioscorea Nardostachys jatamansi*, *Picrorhiza kurrooa, Podophyllum hexandrum*, *Pseudogenseg*, *Rheum Rauwolfia serpentina* and *Withania somnifera.*

Unit - IV

Cultivation packages for important aromatic plants – *Carum carvi*, Citronella, Lemongrass, Mentha, Ocimum, Patchauli, Khus grass, Geranium, Large cardamom, Davana, Lavander and Rosemerry.

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. Aromatic and Medicinal Plants: Yielding Essential oil for Pharmaceutical Perfumery and Cosmetic Industry and Trade by Shiva, MP, (2002).
7. A Handbook of Organic Farming by Sharma, AK, (2004).

SMAP – 407C: Crop Improvement and Seed Production

Unit - I

History of plant breeding. Mode of reproduction, floral biology and pollination mechanism. Qualitative and quantitative characters. Domestication, plant introduction and acclimatization. Importance of polyploidy and self incompatibility in plant breeding.

Unit - II

Methods of crop improvement such as selection, acclimatization and hybridization. Mutation breeding. Heterosis and hybrid vigor. Methods for cross pollinated crops. Methods for self pollinated crops. Crop improvement methods for clonal crops.

Unit - III

Release of new varieties. Quality seed, classes, production practices and maintenance. Seed testing, ISTA rules, different types of seeds. Classes of quality seed - breeder, foundation, registered and certified seeds. Requirements of certified seeds. Genetic, physical purity, germination and other requirements. Operations essential to a seed industry. Seed production, seed processing, seed certification. Maintenance of improved seed.

Unit - IV

Breeding for resistance to biotic stresses – insect resistance, disease resistance, abiotic stresses- heat and cold resistance, mineral stresses, drought resistance.

Suggested Readings:

1. Breeding Research on Aromatic and Medicinal Plants by Johnson, CB, (2005).
2. Plant Breeding by BD Singh, (2005).
3. Plant Breeding by Sharma, JR, (1994).
4. Biopesticides and Bioagents in Integrated Pest Management of Agriculture by Shrivastava, RP(2003).
5. Practical Plant Breeding by SK Gupta, (2005).
6. Principles of Cloning by Cibelli, J., Lanza, RP, Chambel KHS and West MD.
7. Plant Breeding by Khan, MA.
8. Crop Responses to Abiotic Stresses. Vol 2 by D. Kumar.
9. Plant Protection by Trivedi, PC.

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