	Optional courses for 2 credits		
S.N.	**Code No.**	**Courses**	**Credit Hours**
1.	CRP 351	Physiological Techniques in crop production	2 (1+1)
2.	SAC351	Designer fertilizer Production	2 (1+1)
3.	SAC352	Rejuvenation of Deteriorated lands	2 (1+1)
4.	SAC353	Soilless crop production	2 (1+1)
5.	SAC354	Instrumental methods of analysis	2 (1+1)
6.	SST 351	Seed entrepreneurship skill development and management	2 (1+1)
7.	AGR 351	Weed and water management	2 (1+1)
8.	PGP 351	Plant Genetic Resources Collection, Conservation and Utilization	2 (1+1)
9.	NEM 351	Commercial Production of Nematode Antagonistic bio-agents	2 (1+1)
10.	AGM351	Downstream Processing for Industrially Important Microbial Products	2 (1+1)
11.	AGM 352	Microbial Enzymes	2 (1+1)
12.	AGM 353	Microbial Quality and Safety of Foods	2 (1+1)
13.	AGM 354	Plant –Microbe Interaction	2 (1+1)
14.	AGM 355	Quality Control of Bio-inoculants	2 (1+1)
15.	SAC 355	Crop and Pesticide Chemistry	2 (1+1)

CRP 351 Physiological Techniques in crop production (1+1)

Aim

To impart basic knowledge on various functions and processes related to stress physiology, nutrio physiology, hormonal physiology, production physiology, post harvest physiology etc., and their application in crop production.

Unit I Stress physiology

Abiotic Stress: Water deficit – impact of drought on crop productivity -characteristic features of drought tolerant plants, Drought resistance and tolerance mechanisms, Osmotic adjustment and osmoregulation, stress proteins, Water use efficiency – carbon isotope discrimination- Physiological traits associated with drought and Mitigation techniques. Flooding: Physiological mechanism of adaptation, Mitigation techniques, Temperature stress: High and Low Temperature, Tolerance mechanisms - Functions of HSPs and CSPs, Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems – Enzymatic and Non-Enzymatic, Physiological traits associated with high and low temperature, Mitigation techniques. Salt stress: Physiological basis of tolerance mechanisms, Physiological traits associated with salt stress, Mitigation techniques. UV stress and climate change: Physiological adaptation of crops to UV radiation and tolerance mechanisms.

Unit II Nutriophysiology

Diagnosis and correction measures for nutritional disorders including Macro, Micro and secondary nutrients in Cereals, Pulses, Oilseeds, Fibre and Sugar crops; Fruits, Vegetables, Flowers, Spices, Plantation and Aromatic crops. Impact of heavy metals on physiology and productivity of crops, Phytoremediation, Importance of beneficial elements – Na, Si, Se, Co.

Unit III Hormonal physiology

Role of hormones in plant growth and yield enhancement, stress management and quality improvement - Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene and Brassinosteroids. Role of other phytohormones in crop production-triacontanol, polyamines, jasmonates and salicylic acid, New generation PGRs - 1- MCP, Triazoles, strigalactone, pro-hexadione Ca.

Unit IV Production Physiology

Physiological limitations of crop productivity, Physiological and genetic basis of crop environment interaction, Plant architecture – Ideotype concept, Crop photosynthetic efficiency –

C_3 , C_4 and CAM Strategies to improve the crop photosynthesis,Source- sink balance and Harvest Index.

Unit V Postharvest physiology

Environmental factors influencing senescence, ripening and postharvest life of fruits, flowers, vegetables and seeds. Physiological and biochemical aspects of senescence and fruit ripening. Regulatory role of ethylene in senescence and ripening, Pre and post harvest measures to influence shelf life.

Theory Lecture schedule

1. Classification of abiotic stresses - Drought – types-Drought resistance and tolerance mechanisms- adaptations-Physiological traits associated with drought -osmotic adjustment.
2. Reactive Oxygen Species- scavenging enzymes- stress proteins-water use efficiency – carbon isotope discrimination- concept -mitigation techniques.
3. Flooding - Physiological mechanism of adaptation- physiological traits associated with flooding- Role of ethylene.
4. Temperature stress-High and Low Temperature -Tolerance mechanisms-Functions of HSPs and CSPs - Physiological traits associated with high and low temperature.
5. Salt stress - Physiological basis of tolerance mechanisms –adaptations- Physiological traits associated with salt stress.
6. Physiological adaptation of crops to high and low light and UV radiation.
7. Impact of heavy metals on physiology and productivity of crops –Phytoremediation.
8. **Mid Semester examination**
9. Diagnosis and correction measures for nutritional disorders in Cereals, Millets, Pulses, Oilseeds.
10. Diagnosis and correction measures for nutritional disorders in Fibre, Sugar crops, Fruits and Vegetable, Flowers, Spices, Plantation, Medicinal and Aromatic crops.
11. Importance of beneficial elements – Na, Si, Se, Co- Effect of crop specific application of beneficial elements.
12. Role of hormones in plant growth and yield enhancement, stress management and quality improvement – Auxins, Gibberellins and Cytokinins.
13. Role of hormones in plant growth and yield enhancement, stress management and quality improvement –Abscisic acid, Ethylene and Brassinosteroids.

14. Role of other phytohormones -triacontanol, polyamines, jasmonates and salicylic acid. New generation PGRs - 1- MCP, Triazoles, strigalactone, pro-hexadione Ca.
15. Physiological limitations of crop productivity, Physiological and genetic basis of crop environment interaction, Plant architecture – Ideotype concept.
16. Crop photosynthetic efficiency – C_3, C_4 and CAM Strategies to improve the crop photosynthesis, Source- sink balance and harvest index.
17. Environmental factors influencing senescence and ripening-Physiological and biochemical aspects of senescence and fruit ripening-Factors affecting post harvest life of fruits- measures for enhancing the shelf life of fruits, vegetables and flowers.

Practical schedule

1. Determination of osmotic potential
2. Gas Exchange measurements using Infra Red Gas Analyzer
3. Stress induction response techniques
4. Water Use Efficiency or Transpiration Efficiency of crops
5. Estimation of anti oxidant enzymes activity – Catalase and peroxidase
6. Estimation of Membrane thermal stability
7. Bioassay for Cytokinins
8. Effect of PGRs on flowering
9. Effect of PGRs on fruit ripening
10. Influence of ABA on stomatal regulation
11. Diagnosis of nutritional disorders and their amelioration measures
12. Nutrient application techniques
13. Estimation of Macro nutrients in plant samples
14. Estimation of micro and secondary nutrients using AAS
15. Field Visit I- Diagnosis of nutrient disorders
16. Field Visit II-Postharvest storage facilities
17. Final practical

Outcome

Students will acquire basic knowledge on various functions and processes related to stress physiology, nutrio physiology, hormonal physiology, production physiology and post harvest physiology. In addition, hands on exposure to determine osmotic potential, influence of PGRs in

fruit ripening, stomatal regulation, Stress induction response techniques and estimation of macro and micro nutrient will help the student gain confidence in skill oriented education. Student will also get exposure in diagnosis of nutrient disorders which will augment in recommending remedial measures to nutrient disorders and extending the storage life of harvested produce.

Text books

1. Barker AB &Pilbeam DJ. 2007. Handbook of Plant Nutrition. 2nd Edition, CRC Press, Taylor & Francis Group. Pp 1-773.
2. Bewley, J.D. and Black, M. 1985. Seed Physiology of Development and Germination. Plenum Publishing Corp. New York, NY.pp 70-73.
3. Bleasdale, J.K.A. 1984. Plant Physiology in Relation to Horticulture. 2nd Ed. MacMillan & Avi Publishing Company, USA.
4. Leopold, A.C. and Kriedemann, P.E. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill, New York, pp 545.
5. Madhava Rao KV, Raghavendra, AS and Janardhan Reddy K. 2006. Physiology and Molecular Biology of Stress Tolerance in Plants. Springer publishers, Netherland.
6. Taiz. L. and Zeiger. E., 2015 (Sixth edition). Plant Physiology and Development. Publishers: Sinauer Associates, Inc., Massachusetts, USA.
7. Wilkins MB. 1969. Physiology of Plant Growth and Development. Tata McGraw-Hill, New York, pp 127-162.

e- books and e-references

1. http://www.plantphys.net
2. http://www.plantstress.com
3. http://www.ipni.net
4. http://www.edis.ifas.ufl.edu
5. http://www.greenair.com/plantlnk.htm
6. http://www.tvdsb.on.ca

AGR 351 WEED AND WATER MANAGEMENT (1+1)

Unit - I

Weeds: Introduction, Definitions; harmful and beneficial effects, classification,; crop weed competition and allelopathy. Methods of weed control: physical, cultural, chemical and biological methods. Integrated weed management.

Unit - II

Herbicides - Classification, characteristics, formulations, methods of application; advantages-.Weed management in major field crops - aquatic and problematic weeds and their control.

Unit – III

Role of water in plant growth - Importance of irrigation- Soil - water - plant relationship - Soil Plant Atmospheric Continuum (SPAC) - Hydrological cycle - Soil water movement - soil moisture constants - Moisture extraction pattern - Absorption of water.

Unit IV

Crop water requirement- Factors affecting water requirement- Factors affecting water requirement. Scheduling of irrigation – Water use efficiency

Unit V

Methods of irrigation: surface, sub-surface sprinkler and drip irrigation – Micro irrigation: layout, suitability, merits and scope.

Practical

Identification of weeds in wetlands, gardenland and drylands – Practicing different methods of weed control -Calculations on weed control efficiency and weed index; Classification and characteristics of herbicides - Computation of herbicide doses- Study of herbicide application equipment and calibration; Demonstration of methods of herbicide application;

Estimation of soil moisture - Measurement of irrigation water through water measuring devices (flumes, weirs and water meter) - Calculation of irrigation water requirement (problems)- Acquiring skill in land shaping for different surface irrigation methods - Operation and economics of drip and sprinkler irrigation systems - Estimation of crop water requirement - Irrigation efficiency (problems) –

Theory

Lecture Schedule :

1. Weeds - Definition, classification
2. Characteristics of weeds, harmful and beneficial effect of weeds.
3. Crop weed interactions - Critical crop weed competition, competitive and allelopathic effects of weeds and crops.
4. Methods of weed control: physical, cultural
5. Methods of weed control: chemical and biological methods. Integrated weed management.
6. Herbicides - Classification, characteristics, formulations,
7. Methods of herbicide application
8. Weed management in major field crops - aquatic and problematic weeds and their control.
9. **Mid semester examination**
10. Role of water in plants - Importance of irrigation
11. Soil - Plant -water relationship - Soil-plant-atmospheric continuum - Hydrologic cycle - absorption of water and evapotranspiration.
12. Soil water movement - saturated and unsaturated flow and vapour movement - soil moisture constants and their importance in irrigation.
13. Available soil moisture - definition and importance - moisture extraction pattern
14. Crop water requirement - factors affecting crop water requirement -Critical stages for irrigation - water requirement for different field crops.
15. Scheduling of irrigation - Different approaches- Water use efficiency
16. Methods of irrigation - surface (flooding, beds and channels, border strip, ridges and furrows, broad bed and furrows, surge irrigation) and sub-surface methods.
17. Micro irrigation system (drip and sprinkler irrigation) - suitability, components, layout, operation, advantage and disadvantage.

Practical schedule:

1. Identification, classification and characterization of wetland weeds.

2. Identification, classification and characterization of gardenland and dryland weeds.
3. Practicing skill development on cultural and non chemical weed management.
4. Identification, classification and characterization of herbicides.
5. Practicing skill development on herbicide application techniques.
6. Practicing Skill development on spray equipment's and spray fluid calibration.
7. Calculation of herbicide quantity and recommendation for different eco systems
8. Working out weed index, weed control efficiency and economics in weed management studies.
9. Estimation of soil moisture by gravimetric method and tensiometer.
10. Estimation of soil moisture by resistance blocks and neutron probe and other improved devices.
11. Measurement of irrigation water with flumes and weirs.
12. Calculation of irrigation water based on source, water flow, soil moisture status and depth of irrigation.
13. Land leveling and land shaping - Beds and channels - ridges and furrows.
14. Layout, operation and maintenance of drip and sprinkler irrigation systems.
15. Estimation of crop water requirement by direct and indirect methods.
16. Calculations on irrigation efficiency parameters.
17. **Practical examination**

References:

Gupta, O. P. 1998. Modern Weed Management. Agro Botanica Bikaner, India.

Subramanian, S. A. Mohammed Ali and R. Jayakumar. 1991. All about Weed Control. Kalyani Publishers, New Delhi.

Jaganathan R., and R.Jayakumar. 2003. Weed Science Principles, Kalyani Publishers, New Delhi.

Das, P.C. 2015. Weed Science. New India Publishing Agency, Jaipur

Michael, A.M. 1997. Irrigation: Theory and Practice Vikas Publishers.

Sankara Reddy, G.H. and T. Yellamanda Reddy. 1997. Efficient use of irrigation water. Kalyani Publishers

Reddy, S.R.2012.Irrigation Agronomy. Kalyani publishers, NewDelhi

Nirmal Tripathy.2014. Irrigation,Watershed and Drainage. Agrotech Press, Jaipur

Gupta,A.K. 2014. Irrigation and Drainage. Oxford Book Company, Jaipur

Israelsen, O.W. 2012. Irrigatiom Principles and Practices. Axis Books (India), Jodhpur.

Michael, A.M. 2009. Irrigation- Theory and Practice, Vikas Publishing House, Noida

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www.tnau.ac.in

www.fao.org

www.tnau.ac.in/agriportal

www.irri.org
www.wcc.nrcs.usda.gov/nrcsirrig
www.wcc.nrcs.sda.gov/irrig.info.html
www.croinfo.net/irrigschedule.html

AGM 351 DOWNSTREAM PROCESSING FOR INDUSTRIALLY IMPORTANT MICROBIAL PRODUCTS (1+1)

Aim : This course aims to develop the skills of the students in the area of Downstream processing of important microbial products.

Objective: At the end of the course, student would have learnt about various purification techniques available for industrially important microbial products like, antibiotics, amino acids proteins, enzymes, organic acids etc

Unit I - Introduction to Bio separation Processes

Role and importance of bioseparations in biotechnological processes.Problems and requirements of bioproduct purification. Cost- cutting strategies. Characteristics of biological mixtures. Classification of bioproducts - Biological activity, Analysis of purity-Process economics- Capital and operating cost analysis

Unit II - Physical Methods of Separation

Centrifugation and filtration. Cell disruption methods; enrichment operations: precipitation methods- with salts, organic solvents, and polymers; extractive separations - aqueous two-phase extraction, supercritical extraction; adsorption methods; membrane based separation theory - types of membranes, types of membrane processes - dialysis; ultrafiltration; microfiltration and reverse osmosis.

Unit III Physical and chemical methods - Isolation of products

Physico-chemical basis of bio-separation processes. Removal of particulate matter, biomass and insolubles: flocculation; sedimentation; adsorption: isotherm, batch, continuous and scale-up of adsorption; extraction: solvent separation, equipment and modes of extraction. Aqueous-two-phase extraction process, supercritical fluid extraction.Precipitation of proteins-methods and scale-up.

Unit IV Isolation of Products - Chromatographic methods of purification

Chromatography - principles, instruments and performance parameters. Paper, TLC, adsorption, gel filtration, reversephase, ion-exchange, hydrophobic interaction, bioaffinity, pseudo affinity chromatographic techniques; GC, HPLC, HPTLC, FPLC, parafusion chromatography and membrane based chromatographic techniques and sample preparation. Electrophoretic separations.

Unit – V Finishing Operations

Products polishing: Crystallization and drying; Purification of antibiotics, amino acids, enzymes and organic acids, proteins, pigments, plant growth hormones, monoclonal antibodies, human growth hormones – Insulin etc.

Practical

Kinetics of a bacterium / yeast in batch culture- doubling time, specific growth rate and growth curve. Batch cultivation of microbes for product formulation; calibration of pH probe, medium preparation, sterilization, and calibration of dO_2 probe. Inoculation of a bacterial / yeast strain in fermentor for batch production of an enzyme / biomass/ ; estimation of kinetic parameters of product formation, biomass production and substrate utilization. Laboratory centrifugation for separation of biomass from fermentation broth.Filtration and microfiltration for solid-liquid separation. Extraction of crude enzyme from microbial biomass and enzyme assay. Production of microbial secondary metabolites and product recovery. Mechanical cell disruption by homogenization: determination of product release kinetics. Sonication of microbial cell suspensions and determination of product release kinetics.Salting out of proteins by precipitation with ammonium sulphate. Precipitation of proteins with acids or bases: determination of isoelectric point. Batch adsorption of an acid on activated charcoal.Solvent extraction and aqueous two-phase extraction of proteins. Gel-filtration chromatography of a protein - salt mixture.Ion-exchange chromatography of a positively charged protein.Gas chromatography for quantitative estimation of volatiles- ethanol.SDS-PAGE of proteins and determination of molecular weight.

Lecture Schedule

1. Role and importance of bio separations in biotechnological processes. Problems and requirements of bioproduct purification
2. Cost- cutting strategies. Characteristics of biological mixtures. Classification of bio products
3. Biological activity, Analysis of purity. Process economics. Capital and operating cost analysis
4. Centrifugation and filtration-Cell disruption methods
5. Enrichment Operations: precipitation methods(with salts; organic solvents and polymers)
6. Extractive separations; aqueous two-phase extraction; supercritical extraction and adsorption methods
7. Membrane based separation theory - types of membranes; types of membrane processes – dialysis, ultrafiltration, microfiltration and reverse osmosis
8. Physico-chemical basis of bio-separation processes. Removal of particulate matter, biomass and insolubles: flocculation; sedimentation
9. **Mid semester evaluation**
10. Adsorption – Isotherm,batch, continuous and scale-up of adsorption
11. Extraction: solvent separation, equipment and modes of extraction.Aqueous two-phase extraction process, supercritical fluid extraction.
12. Precipitation of proteins: methods and scale-up. Chromatography - principles, instruments and practice
13. Paper; TLC, adsorption, gel filtration; reverse phase, ion-exchange, hydrophobic interaction, bioaffinity ; pseudo affinity chromatographic techniques
14. GC, HPLC, FPLC HPTLC, parafusion chromatography and membrane based chromatographic techniques and sample preparation. and electrophoretic separation
15. Products polishing. Crystallization and drying. Purification of antibiotics
16. Purification of amino acids,organic acids, enzymes and proteins
17. Monoclonal antibodies; human growth hormones – Insulin etc

Practical Schedule

1. Kinetics of a bacterium / yeast in batch culture: calculation of doubling time, specific growth rate, and plotting of growth curve.

2. Preparation of fermentor and accessories for batch cultivation of microbes: calibration of pH probe, medium preparation, sterilization, and calibration of dO_2 probe.
3. Inoculation of a bacterial / yeast strain in fermentor for batch production of an enzyme / biomass: estimation of kinetic parameters of product formation, biomass production and substrate utilization.
4. Laboratory centrifugation for separation of biomass from fermentation broths. Filtration and microfiltration for solid-liquid separation.
5. Extraction of crude enzyme and assay of enzyme
6. Production of secondary metabolites from microbes and recovery
7. Mechanical cell disruption by homogenization: determination of product release kinetics.
8. Sonication of microbial cell suspensions and determination of product release kinetics.
9. Salting out of proteins by precipitation with ammonium sulphate.
10. Precipitation of proteins with acids or bases: determination of isoelectric point.
11. Batch adsorption of an acid on activated charcoal.
12. Solvent extraction and aqueous two-phase extraction of proteins.
13. Gel-filtration chromatography of a protein-salt mixture.
14. Ion-exchange chromatography of a positively charged protein.
15. Gas chromatography for quantitative estimation of volatiles: ethanol.
16. SDS-PAGE of proteins and determination of molecular weight
17. **Final Practical Examination**

Text Books

1. Sivasankar B., 2010. Bioseparations: Principles and Techniques, PHI, New Delhi .
2. Stanbury, P.F., Whitaker, A. and Hall, S.J. 2016. Principles of Fermentation Technology, BH Elsevier Publications, Third Edition.

Reference Books

1. Harrison, R.G. Todd, P., Rudge, S.R. andPetrides, D.P., 2003. Bioseparation Science and Engineering, Oxford University Press.
2. Costa,C.A. and CabralJ.S. 1991. Chromatographic and Membrane Processes in Biotechnology, Publisher: Kluwer Academic Publishers, The Nether lands.
3. Harrison et al. 2006. Bioseparation Science and Engineering. Oxford Univ. Press.

4. Nooralabettu Krishna Prasad, 2010. Downstream Process Technology: A New Horizon in Biotechnology, PHI, New Delhi.
5. Jenkins, R.O. 1992. Product Recovery in Bioprocess Technology, Biotechnology by Open Learning Series, Butterworth- Heinemann, London, Second Edition.

AGM 352 MICROBIAL ENZYMES (1+1)

Aim: Main aim of the course is to impart knowledge on microbial sources of enzymes and their utility in different industries.

Objectives: Student will learn about the microbial enzymes, their characteristics, techniques of microbial enzyme production and use in different industries.

Unit I: Introduction

Introduction and Scope, General distinctive features and industrial applications. Enzymes: Historical perspectives, Nomenclature and classification of enzymes. Isozymes, biological roles, activation energy, chemical nature of enzymes, characteristics of enzymes, 3'D' structure of enzymes, active site, factors affecting enzyme activity, modifiers of enzyme activity, enzyme activators, enzyme inhibitors and allosteric enzymes.

Unit II: Enzyme kinetics

Kinetics of single substrate reactions, Estimation of *Michaelis - Menten* parameters, multi substrate reactions, mechanisms and kinetics, turnover number, types of inhibition, kinetic models: substrate and product inhibition, allosteric regulation of enzymes, *Monod ChangeuxWyman* model, pH and temperature effect on enzymes and deactivation kinetics. Vitamins and their co-enzymes: structure and functions with suitable examples. Metallo enzymes and metal ions as co-factors and enzyme activators.

Unit III: Extraction and purification of microbial enzymes

Importance of enzyme purification, different sources of enzymes.Extracellular and intracellular enzymes. Physical and chemical methods used for cell disintegration. Enzyme fractionation by precipitation - using temperature, salt, solvent, pH, *etc*., Liquid-liquid extraction -ultra filtration, ionic exchange, gel chromatography, affinity chromatography and other special purification methods. Enzyme crystallization techniques.Criteria of purity of enzymes.

Unit IV: Industrial applications of enzyme and enzyme engineering

Industrial applications: Microbial enzymes in textile, leather, wood industries and detergents. Enzymes in clinical diagnostics.Enzyme sensors for clinical processes and environmental

analyses.Enzymes as therapeutic agents. Enzyme engineering: Chemical modification and site-directed mutagenesis to study the structure-function relationship of industrially important enzymes. Cloning- strain improvement.

Unit V: Enzyme formulation

Physical and Chemical techniques for enzyme immobilization – adsorption - matrix entrapment encapsulation - cross-linking - covalent binding - examples; advantages and disadvantages of different immobilization techniques. Freeze drying and spray drying of immobilized enzymes.

Practical

Amylase production using *Bacillus amyloliquefaciens*and its assay.Protease production by using *Bacillus* isolate and its quantification. Production of cellulase by solid state fermentation (SSF) of rice straw through lignocellulolytic fungi: (a) Estimation of filter paper lyase activity (b) Estimation of carboxy methyl cellulase activity. Production and estimation of xylanase from rice straw through submerged fermentation.Immobilization of microbial cells for enzyme production. Protease production from *Bacillus subtilis* using soybean meal.Purification of fungal α - amylase or bacterial protease by fractionation, chromatographic techniques and electrophoretic separation. Studies on enzyme kinetics of alpha amylase / protease-optimization of parameters *viz*., substrate, enzyme concentration, reaction temperature, reaction pH, K_m, V_{max} and metal ions as activators and inhibitors. Enzyme extraction-concentration- ultrafiltration- chromatography- microencapsulation.

Theory schedule

1. Introduction and scope, general distinctive features and industrial applications.
2. Enzymes: historical perspectives, nomenclature and classification .
3. Isozymes, biological roles, activation energy, chemical nature of enzymes.
4. Characteristics of enzymes, 3'D' structure of enzymes, active site, factors affecting enzyme activity.
5. Modifiers of enzyme activity, enzyme activators, enzyme inhibitors; allosteric enzymes.
6. Kinetics of single substrate reactions, estimation of *Michaelis - Menten* parameters, multi substrate reactions, mechanisms and kinetics; turnover number.

7. Types of inhibition; Kinetic models: substrate and product inhibition; Allosteric regulation of enzymes.
8. *Monod Changeux Wyman* model, pH and temperature effect on enzymes and deactivation kinetics.
9. **Mid Semester Examination**
10. Vitamins and their co-enzymes: structure and functions with suitable examples. Metallo enzymes and metal ions as co-factors and enzyme activators.
11. Importance of enzyme purification, different sources of enzymes. Extracellular and intracellular enzymes.
12. Physical and chemical methods used for cell disintegration. Enzyme fractionation by precipitation - using temperature, salt, solvent, pH, *etc*., liquid-liquid extraction.
13. Ionic exchange, gel chromatography, affinity chromatography and other special purification methods. Enzyme crystallization techniques. Criteria of purity of enzymes.
14. Industrial applications: Microbial enzymes in textile, leather, wood industries and detergents. Enzymes in clinical diagnostics. Enzyme sensors for clinical processes and environmental analyses. Enzymes as therapeutic agents.
15. Enzyme engineering: Chemical modification and site-directed mutagenesis to study the structure-function relationship of industrially important enzymes. Cloning- strain improvement.
16. Physical and Chemical techniques for enzyme immobilization – adsorption - matrix entrapment encapsulation - cross-linking - covalent binding - examples;
17. Advantages and disadvantages of different Immobilization techniques - overview of applications of immobilized enzyme systems

Practical schedule

1. & 2. Amylase production using*Bacillus amyloliquefaciens*in submerged and solid state fermentationand its assay.
3. & 4. Protease production using*Bacillus* isolate and its quantification.
5. Production of cellulase by solid state fermentation (SSF) of rice straw through lignocellulolytic fungi - Estimation of filter paper lyase activity.
6. Production of cellulase by SSF of rice straw through lignocellulolytic fungi- Estimation of carboxy methyl cellulase activity.

7. Production and estimation of xylanase from rice straw through submerged fermentation.
8. Immobilization of microbial cells for enzyme production.
9. Protease production from *Bacillus subtilis*using soybean meal.
10. -12. Purification of fungal alpha-amylase or bacterial protease by fractionation, chromatographic techniques and electrophoretic separation.

13-14. Studies on enzyme kinetics of alpha amylase / protease - optimization of parameters *viz*., substrate, enzyme concentration, reaction temperature, reaction pH, K_m, V_{max} and metal ions as activators and inhibitors.

15-16. Enzyme extraction- concentration-ultrafiltration-chromatography-microencapsulation

17. **Final Practical Examination**

Text Books

1. Alexander N. Glazer, Hiroshi Nikaido. 2007. Microbial Biotechnology, Second Edition, ISBN 9780521842105, Cambridge University Press.
2. Trevor Palmer and Philip L. Bonner, 2004. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, East- West Press.

Reference Books

1. Shuler, M.L. and F. Kargi, 2002. Bioprocess Engineering : Basic Concepts, Second Edition, Pearson.
2. Blanch, H.W and D.S. Clark, 1997. Biochemical Engineering, Marcel & Dekker, Inc.,.
3. Bailey, J.E and D.F. Ollis, 1986. Biochemical Engineering Fundamentals, Second Edition, McGraw-Hill.
4. Nicholas C. Price and Lewis Stevens, 1982. Fundamentals of Enzymology, Oxford University Press.
5. Alan Wiseman, 1999. Handbook of Enzyme Biotechnology, Third Edition, Ellis Harwood Publications.

E-Book

1. James Lee, M., Biochemical Engineering, PHI, USA, e-Book Version 2.1, 2002.

AGM 353 MICROBIAL QUALITY AND SAFETY OF FOODS (1+1)

Aim: This course aims in imparting knowledge on microbial quality and safety of foods.

Objectives : At the end of the course the student will be able to learn the techniques of microbial quality assessment and food safety standards**.**

Unit I Introduction

Food safety risks and assessment– characteristic features of spoilage - significance of spoilage of different groups of foods - cereal and cereal products, vegetables and fruits, meat, poultry, sea foods, milk and milk products, packed and canned foods.

Unit IIFood borne infections and intoxications

Food borne pathogens- food infections and intoxications of food borne diseases – bacteria, fungal, protozoa and viral.Investigation and management of food borne diseases.

Unit III Techniques for detection of pathogens and toxins

Advanced laboratory techniques for food-borne pathogens: principle, working and application of GC-MS, HPLC, LC/MS, inductively coupled Plasma Mass Spectroscopy, TOF and PCR-real time PCR.DGGE.Metagenomics, proteomics and immunological methods

Unit IV Food standards

Food standards – HACCP concepts, principles – EU, FDA and WHO standards - CODEX – Food Law & regulations - HACCP principles & applications – GM foods – SSOP – GMP & GAP – Food traceability- Food Audit - functions, duties and responsibilities of food safety regulators.

Practical

Food sampling procedures – Preparation & plan - Examination of microorganisms of by aerobic plate count -Assessing *Bacillus cereus*, coliforms, *Campylobacter*, *Salmonella* and *Staphylococcus* in various food samples. Microbiological examination of canned foods. Rapid detection of pathogens and toxins in foods– HACCP of fruits and vegetables - visit to food processing industry.

Lecture Schedule

1. Food Safety Risks - biological, chemical, physical risks; risk assessment.

2. Physical and chemical changes during food spoilage.
3. Significance of microbial spoilage of different groups of foods - cereals, vegetables and fruits, packed and canned foods.
4. Significance of microbial spoilage of different groups of foods-meat, poultry, sea foods, milk and milk products.
5. Food borne pathogens – food infection – intoxication - bacterial food borne diseases – viral and protozoa.
6. Mycotoxicoses in foods – occurrence and economic significance and food control measures.
7. Analytical techniques and their working principles for the detection of toxin in foods – GC-MS, HPLC and HPTLC.
8. Analytical techniques and their working principles for the detection of toxin in foods - LC/MS, ICP – MS and TOF.
9. **Mid Semester Examination**
10. Molecular Detection of Food borne Pathogens - PCR, real time PCR, DGGE, metagenomics, proteomics and immunological methods
11. Food standards – India, EU, FDA and WHO Standards of Food Safety
12. Food laws & Regulations - CODEX
13. HACCP concepts, principles and applications
14. GM foods and current guidelines for production and labeling
15. Food Safety – Standard Sanitation Operating Procedures; GMP, GAP for food safety
16. Food traceability– significance - Food safety Audit
17. Functions, duties and responsibilities of food safety regulators

Practical schedule

1. Different sampling plan in food and preparation for various foods
2. Determination of aerobic plate counts in food
3. Enumeration of yeasts and molds in food
4. Detection and confirmation of *Bacillus cereus* in food
5. Microbiological hazard analysis in processed fruit product
6. Microbiological hazard analysis in water - water quality control
7. Microbiological hazard analysis in fresh vegetables – *Campylobacter* and *Salmonella*

8. Microbiological hazard analysis in beverages - Detection of coliforms
9. Microbiological techniques for cereal based food analysis
10. Microbiological hazard analysis in meat products - *Staphylococcus aureus*
11. Rapid detection of toxin producing *Escherichia coli* (STEC) in food products –PCR method
12. Detection of aflatoxin in groundnut and maize kernels
13. Hazard Analysis and Critical Control Point (HACCP) of Fruits / vegetables
14. Hazard Analysis and Critical Control Point (HACCP) of processed foods
15. Visit to Food Processing industry
16. Microbiological examination of canned foods
17. **Final Practical Examination**

Text Books

1. Adams, M.R. and Moss, M.O.1995. Food Microbiology. The Royal Society of Chemistry, Cambridge.
2. Frazier, W.C. and Westhoff, D.C.1988. Food Microbiology. TATA McGraw Hill Publishing Company Ltd., New Delhi.

Reference Books

1. Jay, J.M.1987. Modern Food Microbiology. CBS Publishers and distributors, New Delhi.
2. Banwart, G.J.1989. Basic Food Microbiology. Chapman & Hall New York.
3. Board, R.C.1983. A Modern Introduction to Food Microbiology. Blackwell Scientific Publications, Oxford.
4. Robinson, R.K.1990. Dairy Microbiology Elsevier Applied Science, London.
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7. Gould G.W. 1995. New Methods of Food Preservation. Blackie Academic and Professional, London.

AGM 354 PLANT-MICROBE INTERACTIONS (1+1)

Aim: To allow students to explore various ways in which microbes interact with plants, and the outcomes of that interplay. The focus is on examination of the physiological, biochemical and genetic basis of these interactions, using comparisons to other prokaryotic and eukaryotic model systems.

Objectives: At the end of this course students will be able to:

- recognize and distinguish between the different types of plant-microbe interactions
- explain the physiological and biochemical processes underlying major symbiotic and pathogenic relationships
- analyse the design and content of current research studies published in this area of study
- draw connections between the biology of plant-microbe relationships, the impacts of those relationships on plant growth

Unit I Introduction

Introduction to plant - microbe interactions; types of interaction -positive and negative.Plants as microbial habitat.Spermosphere, phyllosphere and endophyticmicroorganisms.Bacterial secretion systems, gene regulation and quorum sensing in bacterial - plant interactions.Role of plant-microbial interactions in soil health and plant growth promotion. Signalling - effect of microbial signalling on plant productivity and plant signalling on microbial diversity and activity in the soil.

Unit II Plant- microbe interaction -I

Beneficial bacteria – *Arthrobacter*, *Azospirillum, Azoarcus Bacillus*, *Burkholderia*, *Frankia*, *,Gluconacetobacter, Herbaspirillum,Paenibacillus*, *Pseudomonas*, *Rhizobium, Streptomyces* and*Xanthomonas* - host interactions and plant growth promotion. *Agrobacterium* induced tumorigenesis and rhizogenesis. Azolla - *Anabaena* symbiosis.

Unit III Plant– microbe interaction -II

Mutualistic fungal symbionts.Ectomycorrhizal and endomycorrhizal fungi. Infection processes. Interactions with host plants and other soil microbes. Infection processes- fungi and toxins. Induced resistance.Secondary product responses and fungal virulence.Lichens, algal and bacterial interaction.

Unit IV Applications – Agriculture and industires

Plant growth promoting bacteria-types and mechanism of plant growth promotion.Biocontrol agents- types and mechanism of action.Induced resistance: Protein defenseresponses and systemic responses.Phytoremediation**.**Industrial application and medicinal applications – antiviral, anti-cancerous, immunosuppressive and antioxidants.

Unit V Techniques to study plant–microbe interactions

Techniques to study plant- microbe interactions - Phytortron, Rhizotron and Confocal Laser Scanning Microscope.

Practical

Collection and assay of root exudates. Characterization of root exudates. Studying the effect of root exudates on selected bacterial population. Isolation of ecto and endorhizosphere microorganisms.Isolation ofspermospheremicorganisms from germinating seeds. Isolation and purification of endophytic and phyllosphere microorganisms from rice. Visit to plantations and collection of ectomycorrhizal fruiting bodies, orchidaceous and ericoid mycorrhizal root samples and lichens. Examination of endomycorrhizal infection in orchids and ericaceous plants. Examination of lichens associated with trees. Collection and examination of *Anabaena azollae* associated with Azolla. Testing rhizogenesis by *A. rhizogenes*in laboratory conditions.

Lecture Schedule

1. Introduction to plant - microbe interactions; types of interaction - positive and negative. Plants as microbial habitat.
2. Role of microbial diversity in soil health and plant growth promotion.
3. Signalling – effect of microbial signalling on plant productivity.
4. Effect of plant signalling on microbial diversity and activity in the soil.
5. Spermosphere andphyllospheremicroroganisms; endophytic microorganisms.
6. Bacterial secretion systems, gene regulation and quorum sensing in bacterial - plant interaction

7.&8. Beneficial bacteria – *Arthrobacter, Azospirillum, Azoarcus, Bacillus, Burkholderia, Frankia, Gluconacetobacter, Herbaspirillum,Paenibacillus, Pseudomonas, Rhizobium, Streptomyces* and*Xanthomonas* - host interactions and plant growth promotion

9. **Mid Semester Examination**
10. *Agrobacterium* induced tumour formation and root proliferation*;* exploitation of tumorigenesis and rhizogenesis. Mutualistic fungal symbionts

11. Ectomycorrhizal and endomycorrhizal fungi. Infection processes. Interactions with host plants and other soil microbes
12. Infection processes - fungi and toxins. Secondary product and fungal virulence
13. Azolla - *Anabaena* symbiosis. Association of lichens with trees
14. Plant growth promoting bacteria- types and mechanism of plant growth promotion
15. Biocontrol agents- types and mechanism of action
16. Induce Resistance-Induced Systemic Resistance (ISR) and Systemic Acquired Resistance (SAR)
17. Protein defense responses and systemic responses

Practical Schedule

1. Collection of root exudates
2. Assay of root exudates – growth regulator/sugars
3. Studying the effect of root exudates on selected bacterial population – well diffusion assay
4. Isolation and purification of ectorhizophere – rhizosphere and rhizoplane microorganisms
5. Isolation and purification of endophytic microorganisms from rice
6. Isolation and purification of phyllosphere microorganisms from rice
7. Isolation and purification of *Rhizobium*
8. Isolation and purification of *Frankia*from*Casuarinaequisetifolia*
9. Visit to plantations and collection of ectomycorrhizal fruiting bodies, lichens, orchid and ericaceous mycorrhizae infected root samples
10. Examination of ectomycorrhizal fruiting bodies and isolation of ectomycorrhizal fungi
11. Examination of lichens associated with trees; orchidaceous and ericoid mycorrhizae fungal infection in plants
12. Examination of AM fungal infection in plants
13. Collection and examination of AM spores from soil
14. Testing *Agrobacterium tumefaciens* induced tumour formation in dicotyledonous plants in laboratory conditions
15. Testing *A. rhizogenes* induced root proliferation in laboratory conditions
16. Collection and examination of endosymbiont associated with Azolla
17. **Final Practical Examination**

Text Books

1. Kamal B., Normand B. and Fouad D. 2009.Plant-microbe interactions.
2. Chrispeels M.J. and D.E. Sadava. 2003. Plants, Genes, and Crop Biotechnology. Jones & Bartlett Publishers, Boston.

Reference Books

1. Susan I. 1992. Fungal-Plant Interactions, Chapman Hall,
2. George A. 2005. Plant Pathology, Academic Press, Fifth Edition.

E books

1. Nautiyal C.S. and Patrice, D. 2008. Molecular mechanism of Plant and Microbe Coexistence, Springer-Verlag Berlin Heidelberg
2. Lugtenberg, B. 2015. Principles of Plant-Microbe Interactions. Microbes for Sustainable Agriculture, Springer International Publishing Switzerland

AGM 355 QUALITY CONTROL OF BIOINOCULANTS (1+1)

Aim: This course aims in imparting knowledge on techniques of quality control of bioinoculants especially nitrogen fixers, nutrient solubilizers and mobilizers and plant growth promotors

Objectives

At the end of the course, the student will be able to learn the techniques of quality control of microbial inoculants.

UNIT I

Overview of bioinoculant production and quality control.Nitrogen fixers-types.P solubilizers and mobilizers.Potassium releasing bacteria.Microbial transformation of micronutrients zinc, sulphur, iron *etc*. PPFM – PGPR. Mass production methods.Introduction to quality control standards.FCO standards.

UNIT II

Quality control of *Rhizobium* inoculants-Purity checking of mother culture-morphological, biochemical and cultural characteristics of *Rhizobium*-Cross inoculation groups-recent classification-methods for testing nodulation-Estimation of nitrogen fixation – direct & indirect methods - Carrier based and liquid inoculants - FCO standards-scope for new formulations-quality control at different stages of production.

UNIT III

Quality control of *Azospirillum* and *Azotobacter* inoculants-purity checking of mother culture-morphological,biochemical and cultural characteristics-different species-Nitrogen fixation-ARA and microkjeldhal method-Quality control at different stages of production-Quality control of PSB- Purity checking of mother culture-Morphological,biochemical and cultural characteristics-Quantitative and qualitative assay for P solubilization-FCO standards.

UNIT IV

Endophytic nitrogen fixation in sugarcane-*Gluconacetobacterdiazotrophicus*- Potash releasing bacteria-Characteristics-Mechanism of K release – PPFM - PGPR and bioinculants for micronutrients-Quality control of Mycorrhizae-Ecto and Endo mycorrhiza-AMF-Morphological

and cultural characteristics-root infection test and spore count-IP by MPN technique-mechanism of P mobilization-Hairy root organ culture.

UNIT V

Cyanobacterialbiofertilizers-types-nitrogen fixing cyanobacteria-Heterocysts-role of akinetes in survival-soil based composite culture-new formulations-quality testing-population by MPN technique-*Azolla-Anabaena* symbiosis-spore inoculum production-rapid methods for quality control of biofertilizers-molecular and immunological methods. Quality of biocontrol agents-*Pseudomonas* and *Trichoderma*.

Practical

Quality control of *Rhizobium*- *Azospirillum*- *Azotobacter*- morphological and biochemical characterization-Nodulation by Roll paper towel technique-N_2 fixation by ARA- sampling methods-population estimation in broth and inoculants by SPC/MPN methods- P solubilzing bacteria- Available P estimation in Pikosviskya's broth - Organic acid production by titrable acidity-Acid and alkaline phosphatase activity - Quantitative estimation- enumeration of population in hydroxy appetite medium- AM fungi- spore count by wet sieving method- root infection studies by staining with tryphan blue-IP estimation by MPN- hairy root culture Potassium releasing bacteria-quantification of K release-population estimation- PPFM, PGPR, SOB, Zn solubilizing bacteria-qualitative and quantitative assays-Cyanobacteria- Composite culture-enumeration of population by haemocytometer count and MPN technique-*Azolla*-determination ofheterocyst frequency-sporocarps-spore inoculum production- rapid methods for quality control- Molecular methods –immunological methods.

Lecture schedule

1. Overview of bioinoculant production and quality control
2. Nitrogen fixing microbes-symbiotic , associative symbiotic, nonsymbiotic and endophytic nitrogen fixation-Mechanism of nitrogen fixation
3. Phosphate solubilizing and mobilizing microbes-Mechanism of action
4. Potash releasing bacteria -PPFM-PGPR- Zinc solubilizers- Sulphur oxidizers-mechanism
5. Mass production methods of bacterial, fungal and algal biofertilizers
6. Introduction to quality control standards-BIS-FCO standards - Sampling methods

7. Purity checking of *Rhizobium* mother culture-Morphological, biochemical and cultural characteristics-cross inoculation groups-recent classification

8. *In vitro* methods for testing nodulation- Roll paper towel technique-MPN counts, growth pouches/tubular pots -N_2 fixation-direct & indirect methods –N estimation by Microkjeldahl method,^{15}N technique & ARA-principles & methods-enumeration of population at different stages of production

9. **Mid Semester Examination**

10. Criteria for selection of carrier material-FCO standards (2011) for carrier based and liquid Inoculants-scope for new formulations

11. Purity checking of *Azospirillum* and *Azotobacter* mother culture- morphological, biochemical and cultural characteristics-different species

12.Phosphobacteria-organisms involved-purity checking of mother culture- morphological, biochemical and cultural characteristics-quantification-available P estimation in broth-organic acid production-acid and alkaline phosphatase

13. FCO standards for *Azospirillum*, *Azotobacter* and phosphobacteria-quality control of inoculants at different stagesof production- Rapid methods for quality control-molecular and immunological methods. Quality of biocontrol agents-*Pseudomonas* and *Trichoderma*.

14. Potassium releasing bacteria- organisms involved-morphological, biochemical and cultural Characteristics-mechanism and quantification of K release

15. Endophytic nitrogen fixation-*Glucanoacetobacterdiazotrophicus*-PPFM, PGPR-bioinoculants for micronutrients *viz*., sulphur, zinc and iron

16. Ecto and Endo mycorrhizae-AM fungi-morphological and cultural characteristics-mechanism of P mobilization-quality control-root infection-spore count and IP by MPN

17. Nitrogen fixing cyanobacteria-heterocysts-role of akinetes in survival-soil based composite culture-quality checking by MPN technique-*Azolla*-Anabaena symbiosis-heterocyst frequency-sporocarps-spore inoculum production-storage and shelf life

Practical schedule

1. Sampling methods and study of different inoculants-carrier based and liquid inoculants
2. Morphological, cultural and biochemical characterization of *Rhizobium*
3. Purity checking of *Rhizobium* strains-Leonard Jar, germination paper roll and tubular pot

methods-MPN counts

4. Morphological, cultural and biochemical characterization of *Azospirillum*
5. Morphological, cultural and biochemical characterization of *Azotobacter*
6. Estimation of N_2 fixation- Acetylene Reduction Assay of nodules/cultures
7. Estimation of N_2 fixation in broth under *in vitro* conditions-Microkjeldahl method
8. Quantitative and qualitative assay for phosphobacteria-Available P estimation in Pikosviskya's broth by Olsen's method and organic acid production by titrable acidity
9. Assay of acid and alkaline phosphatase activity of phosphobacterial cultures
10. Enumeration of population of *Rhizobium* at different stages of production with Congo red YEMA by SPC method
11. Enumeration of population of *Azospirillum* different stages of production with N free bromothymol blue (Nfb) semi solid medium by MPN method
12. Enumeration of population of *Azotobacter* at different stages of production with Waksman No.77 medium by SPC method
13. Enumeration of population of phosphobacteria at different stages of production with Sperber'shydroxy appetite medium by SPC method
14. Quality control of AM fungi-Spore count by wet sieving, root infection by Tryphan blue staining and Infective propagules by MPN
15. Potassium releasing bacteria- quantification of K release
16. Cyanobacterial inoculants-microscopic examination, determination of heterocyst frequency& population estimation by haemocytometer count and MPN method
17. **Final Practical Examination**

Text books

1. Maheshwari, D. K. and R.C.Dubey, 2008. Potential Microorganisms for Sustainable Agriculture - A techno-Commercial Perspective. I.K.International Publishing House Pvt.Ltd., New Delhi and Bangalore
2. Rai, M.K. 2006. Hand book of microbial biofertilizers. CRC press.

Reference Books

1. Bagyaraj, D.J. and A. Manjunath. 1990. Mycorrhizal symbiosis and plant growth, Univ. of Agricultural Sciences, Bangalore, India.

2. Kannaiyan S. 2002. Biotechnology of Biofertilisers. Kluwer Academic publishers &Narosa Publishing House.
3. Motsara M.R., Bhattacharya P., and Srivastava B. 1995. In: Biofertilizer Technology, Marketing and Uses -A Source Book cum Glossary. Fertilizer Development and Consultancy Organization, New Delhi.
4. Somasegaran, P. and H.J.hoben.1985. Methods in Legume-*Rhizobium* Technology, NifTAL Project and MIRCEN, University of Hawaii, Paia, USA
5. SubbaRao, N. S. 1993. Biofertilizers in Agriculture and Forestry. Oxford and IBH Publishing Co. Ltd., New Delhi.

e-books/ materials

1. Biofertilizers and Organic Fertilizers in Fertilizer (Control) Order, 1985
2. FNCA biofertilizer project group, 2006. Biofertilizer Manual, Japan Atomic Industrial Forum, MEXT, Tokyo, Japan.

SAC 351 DESIGNER FERTILIZER PRODUCTION (1+1)

Aim

This course is aimed to impart knowledge on the production, characterization, evaluation and economics of various designer fertilizers. Further, it also provides guidelines for establishing a designer fertilizer production unit.

Theory- Syllabus

UNIT I

Designer Fertilizers - Definitions - Concepts - Historical development - Scope and Need - Scenario of Multi nutrient deficiencies in soils and plants.

UNIT II

Designer Fertilizers – Classification- Production and Characterisation - Speciality / Customized fertilizer mixtures - Fortified fertilizers - Pelleted fertilizers - Multi nutrient liquid formulations.

UNIT III

Foliar Formulations - Leaf nutrient analysis -Value added fertilizers- enriched with organics/chelates- methods and guidelines for preparing designer Fertilizers- Filler materials- Industries and approved formulations.

UNIT IV

Quality of Designer fertilizers- Compatibility of fertilizer materials - issues in storability, hygroscopicity, clogging, etc. - Toxicity - Advantages and Disadvantages - Key Challenges - Crop response to designer fertilizers - Agricultural, Horticultural, high value crops- yield and quality - Soil health - Nutrient use efficiencies

UNIT V

Feasibility of using designer fertilizers for drip fertigation- Poly houses - roof gardening- Quality Standards- Specifications - Guidelines for Patenting, Licensing and Registration of newer products

Lecture Schedule

1. Designer Fertilizers - Definitions - Concepts -Historical development
2. Scope and need for Designer Fertilizes –Multi nutrient deficiencies in soils and plants - Critical limits - current scenario of multi nutrient disorders
3. Classification-Types- Speciality / Customised, Fortified and Pelleted fertilizers, Multi-nutrient liquid formulations
4. Speciality / Customised Fertilisers- Definitions- Production-characteristics-sources - suitability for crops -Merits and Demerits
5. Fortified fertilizers-Definitions- Production-characteristics-sources-suitability for crops-Merits and Demerits
6. Pelleted fertilizers - Definitions- Production- characteristics- sources- suitability for crops -Merits and Demerits
7. Multi nutrient liquid formulations - Definitions- Production- characteristics-sources - suitability for crops -Merits and Demerits
8. Foliar Formulations - Leaf nutrient analysis - organic and synthetic chelates
9. Mid semester examination
10. Value added fertilizers- enriched with organics/chelates
11. Methods and guidelines for preparing designer Fertilizers - Filler materials
12. Industries and Approved formulations and mixtures - Advantages and Disadvantages - Key Challenges
13. Quality of designer fertilizers - Compatibility of fertilizer materials - issues in storability, hygroscopicity, clogging, etc - Toxicity
14. Crop response to designer fertilizers - Agricultural and Horticultural crops- Yield and Quality- Soil health and Nutrient use efficiencies
15. Feasibility of using designer fertilsiers for drip fertigation - Poly houses - roof gardening
16. Quality Standards-Specifications for designer fertilisers
17. Guidelines for Patenting, Licensing and Registration of newer products

Practical Syllabus

Preparation of Designer Fertilizer Mixtures for major agricultural, Horticultural and High value crops- Preparation of multi nutrient liquid formulations for drip fertigation, poly houses, roof gardening - Preparation of pelletised fertilizer mixtures for high value crops and roof gardening- Preparation of fortified fertilizer mixtures for major agricultural and horticultural crops- Preparation of value added fertilsiers - Assessing the storability of the formulations and mixtures -Machineries in designer fertilizer production - Computation of cost effectiveness of the designer fertilizers - Visit to Designer Fertilizer manufacturing Unit- Protocols for establishing a Designer Fertilizer Production Unit - Procedures for Licensing, registration and Patenting.

Practical schedule

1. Preparation of Designer Fertilizer Mixtures for major agricultural crops: Rice/ Pulse
2. Preparation of Designer Fertilizer Mixtures for major horticultural crops : Banana/ Tapioca
3. Preparation of Designer Fertilizer Mixtures for high value crops : Turmeric/Cotton
4. Preparation of multi nutrient liquid formulations for drip fertigation : Sugarcane/Turmeric
5. Preparation of multi nutrient liquid formulations for poly houses: Tomato/ Cucumber/Capsicum
6. Preparation of pelletised fertilizer mixtures for high value crops : Maize/ Turmeric/Cotton
7. Preparation of pelletised fertilizer mixtures for roof gardening : Chillies/ Brinjal/ Greens
8. Preparation of fortified fertilizer mixtures for major agricultural crops: Maize, Groundnut
9. Preparation of fortified fertilizer mixtures for major horticultural crops: Onion, Bhendi
10. Preparation of value added fertilizers
11. Assessing the storability of the mixtures and formulations
12. Machineries in designer fertilizer production
13. Computation of cost effectiveness of the designer fertilizers

14. Visit to Designer Fertilizer manufacturing Unit
15. Protocols for establishing a Designer Fertilizer Production Unit - Guidelines and budget
16. Procedures for Licensing, registration and Patenting
17. Final practical examination

Outcome

- Acquiring technical knowhow and skills on preparing various designer fertilizer mixtures and formulations to establish a designer fertilizer production unit as an entrepreneur

References

1. Hagin, J. and B. Tucker (2012). Fertilization of Dry land and Irrigated Soils, Springer Science & Business Media, 06-Dec-2012 - Technology & Engineering, 190 pages
2. John Havlin, Samuel L. Tisdale, James D. Beaton, Werner L. Nelson (2013) Soil Fertility and Fertilizers: An Introduction to Nutrient Management, Pearson, 2013 - Technology & Engineering - 516 pages
3. Hari Lal Singh Tandon (2012) Fertilizer Management: Balance-efficiency-profitability Fertilizer Development and Consultation Organization, Arid regions agriculture - 187 pages
4. Anac,D. and P.Martin Pravel (1999).Improved crop quality by nutrient management , Kluwer Academic Publications, London Springer Science & Business Media, 30-Sep,1999 - Science - 310 pages
5. Gustafson,A.F. (2013) Handbook of Fertilizers - Their Sources, Make-Up, Effects, And Use,Read Books Ltd, 16-Apr-2013 - Technology & Engineering - 170 pages
6. Kolay,A.K.(2007) Manures and Fertilizers Atlantic Publishers & Dist, Fertilizers - 173 pages

7. UN Industrial Development Organization(1998), Fertilizer Manual, Int'l Fertilizer Development Center, Springer Science & Business Media, 31-Mar-1998 - Nature - 616 pages
8. Casper, M. S. (1973).Liquid fertilizers, Noyes Data Corp., 1973 - Technology & Engineering - 268 pages

SAC 353 Soilless Crop Production (1+1)

Aim : To introduce the techniques of growing plants without soil or minimal soil and outline the field of application of soilless cultivation systems in commercial greenhouse production. The course will provide a sufficient background on the physical and chemical properties of substrates and necessary knowledge on the chemistry of nutrient solutions to the students and enable them to calculate nutrient solutions of any desirable composition. Further, provide advanced knowledge on automated methods of nutrient and water cycling in various soilless cultivation systems.

Unit I

Protected agriculture overview and scope - Introduction to soilless cultivation of plants - History of solution culture - Present status of hydroponics - Nutrient requirements - Absorption of nutrients by the roots and interaction between the roots and the soil solution - Nutrient ratios - Effects of pH, EC and nutrient ratios on plant growth, yield and quality

Unit II

Containers - Grow bag / container media – formulations - their properties - Systems with aggregates as substrate - bag culture, container culture, trough culture, thin layer systems, other alternative systems - effect of volume and shape of container. Hydroponic systems - Systems involving solely water as a substrate - deep water culture, floating hydroponics, Nutrient Film Technique, plant plane hydroponics, aeroponics.

Unit III

Container media - Description of substrates -sand, gravel, rockwool, expanded minerals, pumice, zeolite, pyroclastic materials, peat, coir, tree bark, sawdust, wood fibres, etc. - Physical properties – impact of physical properties on irrigation management. Chemical properties - Container media analyses - Total and available nutrients - Microbiology and phytosanitation in container media

Unit IV

Composition of nutrient solution: Calculation of nutrient solutions for open systems/ closed systems: concept of drainage solution plus fresh water - Management of nutrient

solution - Nutrient solution recycling - Irrigation control - characteristics of irrigation systems : capacity, uniformity - Delivery Systems : overhead systems, drip irrigation, sub-irrigation. Irrigation scheduling : preset schedule, sensor-based schedule, transpiration-based schedule

Unit V

Equipments in Soilless culture - Automated delivery of nutrient solution - sensor based monitoring - moisture, nutrient, temperature and humidity sensors - Integrated system development for electronic control of equipments for irrigation and nutrient solution recycling. Nutrient solution disinfection - heating, UV-irradiation, chemical treatments by means of ozone, hydrogen peroxide, chlorine, iodine, etc. - membrane filtration - slow sand filtration

Lectures

1. Importance and scope of protected agriculture; Factors affecting crop growth under protected cultivation – temperature, light intensity, CO_2 and humidity
2. Introduction to soilless cultivation of plants; Various systems of soil-less crop production - bag culture, container culture, trough culture, thin layer systems, other alternative systems..
3. History of solution culture and Present methods of hydroponics - deep water culture, floating hydroponics, Nutrient Film Technique, plant plane hydroponics, aeroponics. - Basic needs and suitable crops for hydroponics.
4. Calculation of nutrient solution – mixing of nutrients, concentration and method, dose and time of application; Management of nutrient solution.
5. Fertilization - Nutrient requirements by crops, absorption of nutrients, nutrient ratios and its effect on crop growth and yield; Sensor based nutrient management.
6. Containers – kinds of substrates - sand, gravel, rockwool, expanded minerals, pumice, zeolite, pyroclastic materials, peat, coir, tree bark, sawdust, wood fibres, etc. – resources and methods of preparation.
7. Physical properties of substrates - air to water ratios, bulk density, particle size distribution, porosity, water release curves, hydraulic conductivity
8. Chemical properties of substrates - pH, electrical conductivity, ion sorption, ion exchange, concentration and composition of ions, cation exchange capacity.

9. Mid semester examination
10. Standardization of soil-less media and solution culture
11. Irrigation systems – Drip irrigation, sub-irrigation, matric suction irrigation and irrigation management.
12. Automated irrigation system – sensor based, transpiration based schedule
13. Equipments used in soil-less cultivation – various sensors used
14. Sterilization of substrate in grow bag media and disinfection of nutrient solution in hydroponics.
15. Day to day maintenance of soil-less system of crop production.
16. Suitability of crops for growing under green house cultivation; specific technology for raising vegetable crops under protected cultivation.
17. Economics and Business opportunities in soil-less system of crop production.

Practical

Propagation of plants for culture by hydroponics - testing seeds or cutting using media for adaptation to soilless culture - Growing crops in solution culture observation on growth and maturity phases - Growing crops in water culture and identification of plant nutrient deficiencies / nutritional stresses - Control of acidity of solutions by regulation of pH of nutrient solutions or by control of the sources of N - Formulation of nutrient solutions - Factors governing stability of Nutrient solutions - solubility of salts, purity of constituents, buffering of acidity, quality of water - Regulation of salinity in nutrient solutions – record of change in concentration of soluble salts in nutrient solutions - Culture of plants by nutrient film technique – growing plants using thin layers of water which flow by roots in a designed chamber -Evaluation of solid media in solution culture – growth of plants in solid media - sand, gravel, sawdust, perlite, etc.- Visit to commercial hydroponics greenhouse

Schedule

1. Preparation of soilless media using different substrates for grow bag method and sowing crop.
2. Preparation of solution culture for hydroponics and sowing crop.
3. Estimation of physical characteristics of grow bag media (cocopeat, vermiculite)
4. Determination of chemical properties like pH, EC, CN ratio of grow bag media.

5. Determination of water soluble and exchangeable nutrients in grow bag media.

6. Evaluation of porosity of medium based on moisture characteristic/ water retention curve.

7. Computation of container capacity, air filled porosity of grow bag media

8. Estimation of moisture constants by pressure plate apparatus and computation of available water and water holding capacity.

9. Preparation of common nutrient solution for hydroponics and drip system.

10. Preparation of fertilizer pellet packs for crops under matric suction irrigation.

11. Nutrient monitoring study using sensors in grow bag media.

12. Nutrient monitoring study using sensors in continuous recycling solution culture.

13. Assembling water lines and measurement of water consumption under drip / matrix suction irrigation.

14. Recording of operations involved in devices – peristaltic pump, filter pump, injectors, solenoid valves

15. Study of circuitry for sensor based nutrient monitoring system with wireless controls.

16. Visit to successful greenhouse cultivation system

17. Practical examination

Outcome

As population increases and arable land declines, people will turn to new technologies like soil-less crop production to feed the growing population. Soil-less culture will help to improve the yield and quality of the produce so that we can ensure food security of our country.

References

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Mengel, K. and Kirkby, E.A. 2001. Principles of Plant Nutrition (5th ed). Kluwer Academic Publishers, Dordrecht.

Raviv, M and Lieth, J.H. (eds.) 2008. Soilless Culture, Theory and Practice. Elsevier, London.

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SAC 354 Instrumental Methods of Analysis (1+1)

Objective

To familiarize students with the design, operational principles and practical applications of modern instruments used for the quantitative analysis of soil, plant water, manure and fertilizer samples

Unit I

Principles of instrumentation- classification of instrumental methods – selection of instruments - Principles involved in digestion methods – dry ashing and wet digestion – open vs closed digestion - Block digester , microwave digester and IR digestion systems - components -operation - special consideration

Unit II

Automated methods – Principle and applications - Total N analyser, CN analyser

Unit III

Optical methods – spectrophotometry – visible, ultraviolet and infrared spectrometry - Principle - Instrumentation – sample handling and measurement - method development and validation - accuracy

Unit IV

Emission and absorption Spectroscopy - principles and applications - flame photometry, atomic absorption spectrophotometry, inductively coupled plasma emission spectrometry - instrumentation - features and operation of components - sample handling - errors - fault finding - trouble shooting

Unit V

Chromatography techniques – classification - paper chromatography, TLC - Gas chromatography- HPLC , GC – MS - principles - Instrumentation - sample preparation and handling - errors – trouble shooting

THEORY SCHEDULE

1. Basic principles in instrumental method of analysis
2. Principle and practice of digestion methods
3. Principle and practice of N analyser and CN analyser

4. Spectrophotometry : Types, Principle and instrumentation
5. Spectrophotometry: Sample handling and measurement, method development and validation and checking for accuracy
6. Emission spectroscopy (Flame Photometer) : Instrumentation, interferences, trouble shooting and maintenance
7. Absorption spectroscopy (Atomic Absorption Spectrophotometer) : Principle, instrumentation, features and operation of components
8. Absorption spectroscopy (Atomic Absorption Spectrophotometer) : Sample handling and measurement, errors due to molecular and ionic species, matrix effect and other interferences, trouble shooting and maintenance
9. Mid semester examination
10. Absorption spectroscopy (Inductively Coupled Plasma Emission Spectrometer) : Concepts and instrumentation
11. Absorption spectroscopy (Inductively Coupled Plasma Emission Spectrometer) : Preparation of samples and standards, interferences, trouble shooting and maintenance
12. Principle and practice of paper chromatography, Thin layer chromatography
13. Gas chromatography : Principle, Types and instrumentation
14. Gas chromatography : Operation ,sample handling, maintenance and trouble shooting and applications
15. High Performance Liquid Chromatography : Principle, Instrumentation and operation
16. High Performance Liquid Chromatography : Sample preparation , method development, maintenance and troubleshooting
17. GC – MS : Principle , instrumentation, Sample preparation , method development, maintenance and troubleshooting

PRACTICAL

Collection and processing of samples - Digestion of samples – block digester and microwave digester methods - N analyser – Specrophotometry - UV –Vis Spectrophotometer -- Emission spectroscopy - Flame photometer – Absorption spectroscopy – Atomic Absorption Spectrophotometer (AAS) and Inductively Coupled Plasma Emission Spectrometer (ICP) – Chromatography - Gas Chromatography and High Performance Liquid Chromatography- Procedures for establishing a analytical laboratory

PRACTICAL SCHEDULE

1. Collection and processing of samples (Soil, plant, water, manure and fertilizer)
2. Digestion of samples by block digester/microwave digester and sample preparation for different analysis

3. N anlyser : Calibration , sample estimation and results interpretation
4. UV -Vis spectrophotometer : Getting acquainted with parts of UV -Vis spectrophotometer and preparation of standards
5. UV -Vis spectrophotometer : Calibration, sample estimation (P/S/B) and results interpretation
6. Flame photometer : Getting acquainted with components of flame photometer and preparation of standards, calibration, sample estimation (P/S/B) and results interpretation
7. Getting acquainted with components of AAS and standards (micronutrients and heavy metal) preparation
8. Calibration and sample estimation for micronutrients and heavy metals by AAS
9. Getting acquainted with components of ICP
10. Calibration , sample estimation for elements by ICP and results interpretation
11. Analyte extraction from sample and separation for GC
12. Calibration , sample introduction and interpretation of results in GC
13. Analyte extraction from sample and separation for HPLC
14. Calibration, sample introduction and interpretation of results in HPLC
15. Visit to a analytical laboratory (Government/Private)
16. Procedures for establishing a analytical laboratory – Guidelines and budget
17. Practical examination

Outcome : At the end of the course the student will be able to handle sophisticated instruments. The knowledge earned will help in establishing a analytical laboratory for analyzing soil/plant/water/fertilizer/manure samples.

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SAC 352 Rejuvenation of Deteriorated Lands (1+1)

Objective To impart knowledge related to various factors and processes of land deterioration and their rejuvenization techniques.

Theory syllabus

Unit I

Type, factors and processes of soil / land deterioration and its impact on soil productivity, including soil fauna, bio deterioration and environment. Land rejuvenization and conservation / management techniques; afforestation and sylviculture and soil carbon restoration.

Unit II

Causes, reclamation and management of soil physical deterioration - surface and sub surface hard pans, shallow, slowly permeable and highly permeable and fluffy paddy soils; soil erosion, ravine and sand dune, coastal and seasonally inundated soils and mined land.

Unit III

Causes, reclamation and management of salt-affected soils – saline, sodic and saline sodic soils; acid and acid sulphate soils; laterite soils.

Unit IV

Extent, diagnosis and mapping of land deterioration by conventional and modern RS-GIS tools. Monitoring land deterioration by fast assessment and modern tools.

Unit V

Land use policy, incentives and participatory approach for reversing land deterioration; global issues for twenty first century.

Practical syllabus

Determination of gypsum requirement in sodic soils, lime requirement in acid soils and soil erodibility indices – field reclamation of saline, saline-sodic, sodic and acid soils. . Characterization of soil physical constraints - surface and sub surface hard pans,

shallow, slowly permeable soils, and fluffy paddy soils - characterization of mined out and ravine lands, laterite, sand dune, coastal and seasonally inundated soils.

Theory-Lecture schedule

1. Type, factors and processes of soil / land deterioration.
2. Soil / land deterioration impact on soil productivity, including soil fauna, bio deterioration and environment.
3. Land rejuvenization and conservation techniques; Land configuration techniques; Surface / vertical mulching.
4. Afforestation and sylviculture methods; Soil carbon restoration – use of industrial C-rich by products.
5. Causes, reclamation and management of soil physical deterioration - surface and sub surface hard pans, shallow, slowly permeable and highly permeable and fluffy paddy soils.
6. Causes, management of soil erosion.
7. Causes, reclamation and management of mined and ravine lands.
8. Causes, reclamation and management of sand dunes, coastal and seasonally inundated soils.
9. Mid semester examination
10. Causes, reclamation and management of saline and saline sodic soils
11. Causes, reclamation and management of sodic soils
12. Causes, reclamation and management of acid and acid sulphate soils.
13. Causes, reclamation and management of laterite soils.
14. Extent, diagnosis and mapping of land deterioration by conventional and modern RS-GIS tools.
15. Monitoring land deterioration by fast assessment and modern tools.
16. Land use policy, incentives and participatory approach for reversing land deterioration.
17. Global issues for twenty first century.

Practical schedule

1. Practicing field reclamation of saline soils and assessing its impact and cost benefit.

2. Practicing field reclamation of saline-sodic soils and assessing its impact and cost benefit.
3. Practicing field reclamation of sodic soils by gypsum application and assessing its impact and cost benefit.
4. Practicing field reclamation of sodic soils by press mud application and assessing its impact and cost benefit.
5. Practicing field reclamation of sodic soils by spent wash application and assessing its impact and cost benefit.
6. Practicing field reclamation of acid soils and assessing its impact and cost benefit.
7. Practicing management of surface and sub surface hard pans and assessing its impact and cost benefit.
8. Practicing management of slowly permeable and highly permeable and fluffy paddy soils and assessing its impact and cost benefit.

9 to 13. Field visit and characterization of eroded, ravine and mined out lands, sand dune, coastal, seasonally inundated and laterite soils and assessing its management impact and cost benefit.

14. Field visit to agro forestry and sylviculture farms and assessing its impact on soil conservation.
15. Assessing the suitability of industrial byproducts for eco friendly recycling through soil conservation and rejuvenization.
16. Diagnosis and mapping of land degradation using RS and GIS tools.
17. Final Practical examination.

Outcome:

Students will gain knowledge to manage deteriorated lands by suitable ameliorative measures

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Greenland DJ and Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. CABI.

Lal R, Blum WEH, Vailentine C and Stewart BA. 1997. Methods for Assessment of Soil Degradation.

Sehgal J & Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

SAC 355 Crop and Pesticide Chemistry (1+1)

Aim

To impart knowledge on the chemistry and nutritional significance of various field and horticultural crops so as to include them in the breeding and biofortification programmes towards nutritional security. This course will also impart knowledge on different pesticides, their nature and mode of action and their fate in soil so as to monitor their effect on the environment

Unit-I

Chemistry of Agricultural Crops: Chemical constituents of plants - Proximate and ultimate constituents - Chemical composition and nutritional quality of cereals, pulses and forage crops. Chemical composition and nutritional quality of oilseeds and sugarcane. Post harvest changes in Sugarcane.

Unit-II

Chemistry of Horticultural Crops, alkaloids and Essential oils: Chemical composition and nutritional quality of fruits, vegetables, spices, condiments, tuber crops and beverages. Post harvest changes in fruits. Chemistry of medicinal and aromatic plants.

Unit-III

Pesticides and its Formulations: Pesticides - Definition - Classification-Trends in pesticide use. Pesticide formulations -dusts, wettable powders, emulsifiable concentrate, granules. Insecticides - classification-. Characteristics, Mode of action and use of Organophosphates - Carbamates - Pyrethroids , Botanicals, Insect Growth Regulators and Newer insecticides.

Unit-IV

Fungicides and Herbicides : Fungicides - classification of fungicides -properties, mode of action of inorganic, organic and systemic fungicides - Rhodenticides- Zinc phosphide - Aluminium phosphide - Bromodiolone Herbicides - classification - properties

- mode of action of inorganic and organic herbicides like phenoxy compounds, substituted ureas, amides, thiocarbamates, triazines, pyridines, imidazolines and sulphonyl ureas.

Unit-V

Pesticides and Environment : Insecticide Act and Insecticide Rules - Fate of pesticides in soil- Impact of pesticides on environment

Practical

Estimation of moisture, ash, crude protein, P, K and crude fibre in plant samples - Determination of reducing and non-reducing sugars in jaggery — Oil content in Groundnut- Estimation of total solids, ascorbic acid, titratable acidity in fruits- Phenols/ Mucilages in Vegetables - HCN content in Tapioca/ Sorghum - Analysis of pesticides - Physical tests - Bulk density, wettability, suspensibility, Emulsion stability -. Estimation of pesticide residues in soil, water , vegetables, fruits and pesticidal calculations. Visit to Pesticide Testing Laboratory.

Lecture Schedule

1. Chemical composition and nutritional quality of cereals and pulses - Rice, wheat, maize, minor millets, Red gram, blackgram, and soybean. Starch synthesis and protein synthesis
2. Chemical composition and nutritional quality of oil seed crops - Groundnut, sesame, sunflower, castor, coconut and palm.
3. Chemical composition and nutritional quality of sugarcane -Sucrose synthesis - Post harvest changes in sugarcane. Nutritional quality of forage crops.
4. Chemical composition and nutritional quality of fruits - Mango, banana, papaya, grapes, guava, apple and pomegranate. Chemistry of post harvest changes in fruits.
5. Chemical composition and nutritional quality of vegetables- Tomato, bhendi, brinjal, moringa, greens, cauliflower, radish and peas.
6. Chemical composition of spices and condiments (Turmeric, chillies, pepper, ginger, onion, garlic and Beverages (tea and coffee).Tuber crops- Potato & Tapioca
7. Alkaloids in medicinal plants (Cinchona, Gloriosa, Coleus and Aloevera)

8. Pesticides - Definition - Classification-Trends in pesticide use
9. Mid semester Examination
10. Pesticide formulations - dusts - wettable powders, flowables, sprays –Emulsion concentrates – water soluble liquids - granules, fumigants and aerosols - characteristics and uses.
11. Insecticides classification -Characteristics, Mode of action and use of Organophosphates(Chlorpyriphos, Phorate, Dimethoate, Quinalphos and Profenophos)
12. Characteristics, Mode of action and use of Carbamates (Carbaryl, carbofuran, carbosulfan, aldicarb) and synthetic pyrethroids (Deltamethrin, Fenvalerate, Cypermethrin and Lambdacyclothrin)
13. Characteristics, Mode of action and use of Botanicals (nicotine and neem), Insect Growth Regulators (Novaluron, Buprobasin and GABA inhibitors) and *and newer insecticides (Neonicotinoids - Imidachloprid, Thiachloprid, Acetamiprid, Flupendiamide, Fipronil, Emamectin, Thiomethoxam, Indoxacarb, Chlorantraniliprole)*
14. Fungicides - Classification – Inorganics (sulfur) and Organic fungicides (Chlorobenzene and Chlorothalanil) - Characteristics, mode of action and use
15. Characteristics, mode of action and use of Systemic fungicides (Benomyl, Carbendazim, Metalaxyl, Quinones, Diclones, Dicarboximides –vincozolin).
16. Herbicides - Classification of herbicides - Characteristics, Mode of action and use of 2, 4-D, Sulfonyl ureas - Metsulfuron, Pyrosulfuron, Imidazoline, Alachlor, Butachlor, Oxyfluorfen, Fulchloralin, Pendimethalin, Atrazine, Paraquat and Glyphosate. Bisperipac sodium.
17. Fate of pesticides in soil-Impact of pesticides on the environment , Highlights of Insecticide Act -1968 and Insecticide Rules -1971

Practical schedule

1. Sampling, processing and storage of plant materials for chemical analysis - Estimation of moisture and ash content
2. Preparation of tri acid extracts of plant samples -Estimation of P and K in triple acid extract

3. Estimation of crude protein
4. Estimation of crude fibre
5. Estimation of reducing and non-reducing sugars in jaggery
6. Estimation of oil content in groundnut
7. Estimation of total solids, ascorbic acid and titrable acidity in fruit samples
8. Estimation of phenols in vegetables / Mucilages in Bhendi
9. Determination of HCN content in Tapioca/ forage sorghum
10. Determination of bulk density in dust formulation, wettability and suspensibility test in wettable powder formulations
11. Estimation of emulsion stability in EC formulation
12. Estimation of pesticide residues in soil using GC/HPLC
13. Estimation of pesticide residues in Water / Soft drinks using GC/HPLC
14. Estimation of pesticide residues in Vegetables using GC/HPLC
15. Estimation of pesticide residues in Fruits using GC/HPLC & Pesticide requirement calculations
16. Visit to Pesticide Testing Laboratory
17. Practical Examination

Text books

1. Konard Mengel *et al.,* 2006. Principles of Plant Nutrition. 5th Edition, Springer International.
2. Vasanthi ,D, T.Chitdeshwari, M.R.Latha, C.Sudhalakshmi and A.Vadivel,2014. Text book on Crop and Pesticide Chemistry Pp.310
3. Dhakshinamoorthy, M. 2000. An Introduction to Plant Biochemistry and Chemistry of Crops, Suri Associates, Coimbatore Pp.192
4. Handa, S, K,2004. Principles of Pesticides Chemistry, Agrobios (INDIA), Jodhpur.
5. Roy,N.K, 2002. Chemistry of Pesticides.CBSPublishers &Distributors, New Delhi.

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2. Hand book of Agriculture, 2009. Published by Indian Council of Agricultural Research, New Delhi 110 012.Pp.1583
3. Paul H.Moore and Frederik C.Botha. 2014. Sugarcane : Physiology, Biochemistry and Functional Biology (World Agriculture Series). Amazon Publishers, India.
4. Petra Marschner. 2012. Marschner's mineral nutrition of higher plants.3rd Edition. ISBN: 978-0-12-384905-2.Elsevier publications.
5. Yash P. Kalra, 1998, Handbook of Reference Methods for Plant Analysis, Taylor & Francis Group, LLC, New york, London
6. Dodia, D.A., I.S.Patel and G.M.Patel. 2010. Botanical Pesticides for Pest Management. Amazon Publishers, India.
7. Gupta,A.2006. Pesticide Residue in Food commodities. Agrobios Publishers, Jodhpur.
8. Hassall, K.A. 2013. The Chemistry of pesticides, their metabolism, mode of action and uses in crop production. Scientific Publishers, Jodhpur, India.
9. Koul, 0., G.S.Dhaliwal, S.Khohar and R.Singh. 2014. Biopesticides in Sustainabie Agriculture. Progress and Potential. Amazon Publishers, India.
10. Mac Bean, C. 2013. The Pesticide Manual: A World Compendium. Amazon Publishers, India.
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14. www.uvm.edu/extension/cropsoil/wp-content/uploads/turner_refining.pdf
15. journals.cambridge.org/article_S0021859600040156
16. www.intechopen.com/.../pesticides-in-the-modern-world-trends-in-pestic...
17. cibrc.nic.in/insecticides_rules.htm
18. www.agcsa.com.au/static/atm_articles/html/3_3c.html
19. www.agf.gov.bc.ca > Agriculture > Pesticide Wise

Out come:

The students of undergraduate will gain knowledge on chemical composition and nutritional quality of various agricultural and horticultural crops. Proper understanding of chemistry of pesticides will be inculcated among the students. The students will acquire the skills on quality monitoring of crops and pesticides through practices.

PBG 351 Plant Genetic Resources : Collection, Conservation and Utilisation (1+1)

Aim:

To inculcate the knowledge and to expose the students for experiencing on the current status and trends of the science, practices and policies of plant genetic resources with respect to collection, conservation and beneficial use for food and agriculture

Syllabus for theory

Unit I Concepts in agrobiodiversity

Origin and history of agriculture; conservation and agricultural development; the central role of agrobiodiversity: trends and challenges; centers of crop plant origin and diversity; Crop Wild Relatives and their role in crop domestication; dynamics of domestication; concept of gene pool; agrobiodiversity regions of India- geographical distribution of crops of Indian origin

Unit II: Planning and execution of collection missions

Importance and need for collection missions; planning and execution of collection missions ; Logistics for collection; GIS- Information on collection sites; Passport data and its importance in collection missions; use of flora and herbaria for planning collections; National and international policies and procedures to be adopted in collection missions

Unit III : Concepts in PGR conservation

In situ and *ex situ* conservation: concept of biosphere reserves, gene sanctuaries, on-farm conservation, seed genebanks, field genebanks, botanical gardens, herbal gardens, *in vitro* repositories and cryo-genebanks; short-, medium- and long-term conservation, concept of base, active and working collections

Unit IV: International and national policies

International framework and PGR networks; International treaties and policies in relation to agrobiodiversity conservation and sustainable use; CBD , UPOV ; National policies and legal frame work; Organisations; Biodiversity authority; PPV and FR authority; National Biodiversity Authority, IP issues with respect to ITKs and communities safe guarding biodiversity

Syllabus for practical

Concepts and methods for computing biodiversity; Alpha and beta models; Calculation of species richness and endemism. Field visits to biosphere reserves – *in situ* methods of conservation.Visit to Field gene banks and understanding the modalities of conservation. Visit to Ramiah Gene Bank to understand the concepts of medium and long term storage in seed gene banks – Seed acquisition, processing, packing, barcoding, viability monitoring, registration and documentation. Visit to clonal gene banks. Biotechnology in conservation - *In vitro* methods of conservation. Exposure to cryoconservation methods. Concepts of PGR documentation and related web resources. Crop genetic diversity - Concepts of core and mini core collections. Molecular methods in PGR documentation and fingerprinting. Planning a Pre breeding programme with adapted and unadapted germplasm. Crop wild relatives - designing a Pre breeding programme with Crop Wild relatives. PGR- Global and National policies. Learning the institutional policies and modalities in exchange and utilization of PGR at TNAU

Lecture schedule:

1. Origin and history of agriculture; conservation and agricultural development-the central role of agrobiodiversity – Methods to estimate biodiversity- trends and challenges
2. Crop diversity - centers of crop plant origin and diversity , Concepts of gene pools
3. Biodiversity hotspots - Global – Indian- Regions of agobiodiversity
4. Crop wild relatives – domestication of crops
5. Dynamics of crop domestication with special reference to Rice, Wheat, Maize and Tomato
6. Germplasm exploration and collection – Eco-Geographical issues to be considered in planning explorations- – use of GIS and GPS principles during explorations
7. Planning the logistics and execution of collection missions- Global collection missions and achievements
8. Sampling strategies to be adopted in collections – Data recording and handling including passport data, collection of herbaria of samples etc during collection missions
9. Mid semester examination

10. Historical issues related to PGR conservation, scientific basis of PGR conservation – Types :*In situ* and *ex situ* conservation:
11. *In Situ* Conservation methods : concept of biosphere reserves, gene sanctuaries,and on-farm conservation
12. *Ex Situ* conservation methods : Field gene banks and seed gene banks
13. *Ex Situ* conservation methods : Cryo conservation, *in vitro* conservation, DNA banks, conservation of microspores and mega spores
14. Concept of base, active and working collections, core collections and reference sets
15. International framework and PGR networks; International treaties and policies in relation to agrobiodiversity conservation and sustainable use; CBD and UPOV convention
16. National polices: National Biodiversity Authority, PPV & FR authority, IP issues with respect to ITKs and communities safe guarding biodiversity
17. Utilization of Plant Genetic Resources – Pre-breeding concepts for use of adapted and un-adapted germplasm in crop improvement programmes

Final theory Examination

Practical schedule:

1. Concepts and methods for computing biodiversity; Alpha and beta models;
2. Calculation of species richness and endemism
3. Field visits to biosphere reserves – *in situ* methods of conservation
4. Visit to Field gene banks and understanding the modalities of conservation
5. Visit to Ramiah Gene Bank to understand the concepts of medium and long term storage in seed gene banks – Seed acquisition, processing, packing, barcoding
6. Visit to Ramiah Gene Bank to understand the concepts of medium and long term storage in seed gene banks – viability monitoring, registration and documentation
7. Visit to clonal gene banks
8. Biotechnology in conservation - *In vitro* methods of conservation
9. Exposure to cryoconservation methods
10. Concepts of PGR documentation and related web resources
11. Crop genetic diversity - Concepts of core and mini core collections
12. Molecular methods in PGR documentation and fingerprinting

13. Planning a Pre breeding programme with adapted and unadapted germplasm
14. Crop wild relatives - designing a Pre breeding programme with Crop Wild relatives
15. PGR- Global and National policies
16. Learning the institutional policies and modalities in exchange and utilization of PGR at TNAU
17. Practical Examination

1. **Reference Text Books (one or two only):**

1. Engels J.M. and Visser, L. **(**eds.). 2003. A guide to effective management of germplasm collections. IPGRI Handbook for Genebanks No.6. IPGRI, Rome, Italy.

2. Guarino, L., Rao, V.R. and Reid, R. **(**eds.). 1995. Collecting plant genetic diversity. CAB International, Wallingford, UK.

2. **E references:**

1. Food and Agriculture Organization **(**FAO) Commission on Biodiversity for Food and Agriculture; www.fao.org/biodiversity

2. http://www.bioversityinternational.org/uploads/tx_news/Molecular_markers_for_gene bank_management_1082.pdf

SST 351 **Seed entrepreneurship skill development and management 2 (1+1)**

Objective

To update the knowledge and skills of students about the seed entrepreneurship, establishment and management of seed enterprise.

Unit I

Current status of National and Global Seed Industry and future perspectives Seed plan - Supply chain management - Significance of Seed Replacement Rate (SRR) Formal and informal seed sector - Seed trade - Role of International agencies in cross border trading (UPOV, OECD, ISTA, IPPC, AOSA, AOSCA) Varietal registration - Seed legislation and regulatory frame works (Seeds Act and Rules, Seed Control Order 1983 and amendments - PPV&FRA 2001).

Unit II

Seed promotional policies and programmes – NPSD 1988 - National seed policy 2002- Seeds Bill 2004 - EXIM policy - Domestic and International organizations involved in seed business - NSC, SSC,NSAI - International Seed Federation (ISF) - Asia Pacific Seed Association (APSA) - National seed quality regulatory system - Seed Certification Agencies - Notification - Seed Testing Laboratories - Central and Referral laboratories - Uniformity in quality regulation - International Seed quality regulatory system - OECD varietal certification - International Seed analysis certificate - ISTA membership and accreditation system.

Unit III

Seed Export and Import - procedures and guidelines - Germplasm exchange rules and directions - Plant Quarantine system and Sanitary and Phyto Sanitary (SPS) issues and measures for export and import of seeds - NBPGR, FAO - Human resource skill development - Financial requirements and their significance in successful seed company management - Seed company - Corporate affairs – components - Registration and establishment - Grant and issue of license - Seed preference assessment - Seed Rolling Plan - OPVs and hybrids - Role of Seed multiplication Ratio (SMR) - Varietal Replacement Rate (VRR).

Unit IV

Post harvest handling and machineries - Principles of seed drying, cleaning and upgradation - their significance in seed shelf life preservation - Risk coverage of carry over seeds - factors affecting seed storage - infrastructure facilities - ambient and advanced storage structures - Pre and post seed quality control - management checks and balances - their significance in seed trade - Linkages with various organizations for effective seed trade and business management - Farmers centric and market driven strategies for sustaining seed business and achieving seed security - Seed pricing - pricing policies of public and private agencies - strategies - methods and factors affecting prices.

Lecture schedule

1. Current status of National and Global Seed Industry and future perspectives
2. Seed plan - Supply chain management - Significance of Seed Replacement Rate (SRR) - Formal and informal seed sector
3. Seed trade - Role of International agencies in cross border trading (UPOV,OECD, ISTA IPPC, AOSA, AOSCA)
4. Varietal registration - Seed legislation and regulatory frame works (Seeds Act and Rules, Seed Control Order 1983 and amendments - PPV&FRA 2001)
5. Seed promotional policies and programmes – NPSD 1988 - National seed policy 2002- Seeds Bill 2004 - EXIM policy
6. Domestic and International organizations involved in seed business – NSC, SSC,NSAI- International Seed Federation (ISF) - Asia Pacific Seed Association(APSA)
7. National seed quality regulatory system- Seed Certification Agencies- Notification - Seed Testing Laboratories - Central and Referral laboratories - Uniformity in quality regulation.
8. **Mid semester examination**

9. International Seed quality regulatory system - OECD varietal certification - International Seed analysis certificate - ISTA membership and accreditation system
10. Seed Export and Import - procedures and guidelines - Germplasm exchange rules and directions - Plant Quarantine system and Sanitary and Phyto Sanitary (SPS) issues and measures for export and import of seeds - NBPGR, FAO etc
11. Human Resource skill development - Financial requirements and their significance in successful seed company management
12. Seed company - Corporate affairs - components- Registration and establishment - Grant and issue of license
13. Seed preference assessment - Seed Rolling Plan - OPVs and hybrids - Role of Seed multiplication Ratio (SMR) - Varietal Replacement Rate (VRR)
14. Post harvest handling and machineries - Principles of seed drying, cleaning and upgradation - their significance in seed shelf life preservation
15. Risk coverage of carry over seeds - factors affecting seed storage - infrastructure facilities - ambient and advanced storage structures
16. Pre and post seed quality control - management checks and balances - their significance in seed trade - Linkages with various organizations for effective seed trade and business management
17. Farmers centric and market driven strategies for sustaining seed business and achieving seed security - Seed pricing - pricing policies of public and private agencies - strategies - methods and factors affecting prices

Practical schedule

1. Basic components in establishment of seed company and organizational setup - staffing pattern - Registration procedures - Company - seed producer

2. Visit to public and private sector seed companies
3. Preparation of seed rolling plan
4. Visit to seed production plots - Study on field inspection procedures
5. Lay out and designing of seed processing unit and infrastructure
6. Lay out and designing of large and small scale seed storage facilities
7. Layout and establishment of seed quality control laboratory
8. Financial assistance for seed company establishment - Central Sector Seed Schemes - NABARD - Financing organizations
9. Preparation of projects for financial assistance for establishment of seed company - Micro, small and medium enterprises etc.,
10. Project preparation on establishment of seed processing units and seed storage infrastructures for financial assistance
11. Visit to seed dealer and retail outlets
12. Value addition techniques for seed preservation, marketing and minimizing post harvest quality losses
13. Management of legal issues related to seeds - stop sale order, punitive action, punishment and appeal - appellate authority
14. Visit to Seed Testing laboratories - Notified and ISTA accredited
15. Preparation of company status report and analysis of critical issues on sustaining seed business
16. Downgrading of seeds - Upgradation and improvement of seed standards of "sales returned seeds" for placing in market
17. **Final practical examination**

Out come

The students will gain knowledge about the National and International seed trade and seed quality regulation system.

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2. Gurudev Gingh and Asokan, S.R., 1997. Management of seed activity. Oxford and IBH Publishing Co., New Delhi.
3. Ramalingam, C. K.Sivasubramaniam and A. Vijayakumar. 1997. A Guide to seed legislation. Rassi Computers, Madurai
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5. Compendium of Seed Legislation. 2013. Dept. of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India, New Delhi

Online references

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2. www.seednet.gov.in
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4. www.agri.nic.in

NEM 351 Commercial Production of Nematode Antagonistic bio-agents 2 (1+1)

Aim: The course is aimed to inculcate entrepreneurial skill to students and expose them to different aspects in commercial production of biocontrol agents, marketing and economics. The course will also provide hands on training to students in mass culturing and marketing of nematode antagonistic fungal organisms.

SYLLABUS

THEORY:

Unit 1

Concepts and definition of biocontrol agents **–** Economic yield loss caused by plant parasitic nematodes in agricultural and horticultural crops – Ecofriendly management of plant parasitic nematodes - Types of bioagents – Fungal antagonistic organisms – Applications – Dosage - Commercial formulations available in India – Merits and demerits.

Unit 2:

Paecilomyces lilacinus – *Pochonia chlamydosporia* - Morphological identification of colony – Conidiaspore and Chalmydospores identification –- Isolation from eggs - Mode of action – Host range - virulence – effect of biotic and abiotic factors on growth – compatibility with chemical inputs.

Unit 3:

Sterilization – Types and Preparation of sterilizing agents – Equipments used – Principle of autoclave – Principle of Laminar Air Flow Chamber – Fermentor – Laboratory up-keep – Haemocytomenter – Assessment of spore load – colony forming unitis.

Unit 4:

Preparation different culture media – Maintenance of pure culture - Mother culture – Subculturing – Mass culturing techniques – solid and liquid formulations - Commercial Formulations – Carrier materials – Packing – Quality control and shelf life.

Unit 5:

Market demand analysis - Economics – Establishment of pilot plant – Infrastructure - Budget preparation – Marketing and cost-benefit analysis – risk
analysis – Environmental impact test with vertebrate and invertebrate organisms.

LECTURE SCHEDULE

1. Introduction - Economic yield loss caused by plant parasitic nematodes in agricultural and horticultural crops. Concepts and definition of biocontrol agents.
2. Types of bioagents – Fungal antagonistic organisms – Applications – Dosage - Commercial formulations available in India – Merits and demerits
3. *Purpureocillium lilacinum (=Paecilomyces lilacinus)* – Morphological identification of colony, phialids and conidia spore
4. *Pochonia chlamydosporia* - Morphological identification of colony. Conidia spore and Chalmydospores identification
5. Isolation of *P. lilacinum* and *P. chlamydosporia* from nematode eggs and mode of action.
6. Host range of *P. lilacinum* and *P. chlamydosporia* - virulence and effect of biotic and abiotic factors on growth – compatibility with chemical inputs
7. Sterilization – Types and Preparation of sterilizing agents – Equipments used for production of bioagents.
8. Principle of Autoclave, Laminar Air Flow Chamber and Fermentor
9. Laboratory up-keep – Preparation of cleaning solutions – preparation of stock solutions
10. Haemocytomenter – Assessment of spore load – colony forming units.

11. Preparation of different culture media – Maintenance of pure culture - Mother culture – Subculturing
12. Mass culturing techniques – solid and liquid formulations – Shelf life
13. Commercial Formulations – Carrier materials – Packing – Quality control and shelf life.
14. Market demand analysis – Economics
15. Establishment of pilot plant – Infrastructure requirement – cost analysis
16. Budget preparation – Marketing and cost-benefit analysis – risk analysis
17. Environmental impact test with vertebrate and invertebrate organisms

PRACTICAL:

Plant parasitic nematodes eggs isolation – Eggs parasitization tests with *Paecilomyces lilacinus* and *Pochonia chlamydosporia* – Fungal specific media preparation – Pure culture - Preparation of common culture media – subculturing of *Paecilomyces lilacinus* - subculturing of *Pochonia chlamydosporia* – Preparation of broth – Inoculation – Incubation in mechanical shaker – *In vitro* bioefficacy test on root knot nematode - Fermentation process – Haemocytometer – Assessing spore load in broth – Preparation of commercial formulation – Quality control test - Packing – Analyzing market potential and demand – Conducting environmental impacts test with termites, saprophytes, honeybees, earthwarm etc., - Visit to commercial production unit (HRS, Ooty).

1. Isolation of eggs of plant parasitic nematodes.
2. Eggs parasitization tests with *Purpureocillium lilacinum*
3. Eggs parasitization tests with *Pochonia chlamydosporia*
4. Fungal specific media preparation – Pure culture - Preparation of common culture media
5. Subculturing of *P. lilacinum* and *Pochonia chlamydosporia*
6. Preparation of broth – Inoculation – Incubation in mechanical shaker
7. *In vitro* bioefficacy test on root knot nematode with *Purpureocillium lilacinum*
8. *In vitro* bioefficacy test on root knot nematode with *Pochonia chlamydosporia*
9. Fermentation process
10. Haemocytometer – Assessing spore load in broth
11. Preparation of commercial formulation
12. Quality control test Packing
13. Analyzing market potential and demand
14. Conducting environmental impacts test with termites, saprophytes,
15. Conducting environmental impacts test with honeybees, earthworm
16. Visit to commercial production unit (HRS, Ooty).
17. Practical Examination