UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

COURSE SYLLABUS
FOR
Ph.D. DEGREE PROGRAMME

2022-23

DIRECTORATE OF POST GRADUATE STUDIES
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

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CONTENTS

* Stand-alone Programme

Ph.D. in Agri-Business Management

Course Code	Course Title	Credit Hours
ABM 601	Econometrics for Agri Business	3(2+1)
ABM 602	Research Methods - I	3(2+1)
ABM 603	Agri Input & Output Marketing	3(2+1)
ABM 604	Research Methods - II	3(2+1)
ABM 605	Natural Resource Management	2(2+0)
ABM 606	Knowledge Management	2(2+0)
ABM 607	Value Chain Management in Agribusiness	2(2+0)
ABM 608	Agri-Entrepreneurship and Corporate Governance	2(2+0)
ABM 609	International Food and Agri Business	2(2+0)
ABM 610	Communication for Management Teachers	2(2+0)
	Total	**24(20+4)**
ABM 680	Qualifying Examination	3 (0+3)
ABM 681	Seminar -I	1 (0+1)
ABM 682	Seminar - II	1 (0+1)
ABM 683	Teaching Assistantship -I	1 (0+1)
ABM 684	Teaching Assistantship - II	1 (0+1)
ABM 691	Research -I	18 (0+18)
ABM 692	Research -II	18 (0+18)
ABM 693	Research -III	18 (0+18)
ABM 694	Research -IV	18 (0+18)

ABM 601 ECONOMETRICS FOR AGRI-BUSINESS (2+1)

Objective

The course is mainly designed to solid data base analysis of market and policy va riables to back up their business strategies. The emphasis will be given on application rather than theoretical details.

Theory

Block I: Over View of Econometrics

Unit1: Introduction: Correlation theory, Basic concept of regression analysis, assumptions of regression model, theory of OLS, properties of least square estimates, maximum likelihood, hypothesis testing, interval estimation, prediction in linear regression model.

Unit 2: Hetero skedasticity and autocorrelation, multi co-linearity, specification errors, selection of regressors, dummy variables, autoregressive and distributed models.

Block II: Application of Econometrics for Agribusiness

Unit 1: Set of regression equations, causality and simultaneity: application.

Unit 2: Time series econometrics- stationarity, unit roots and co-integration, error-correction model, AR, MA, ARMA, ARIMA processes. Qualitative dependent variables – LPM, Logit and probit models.

Practical

- Single equation two variable model specification and estimation – hypothesis testing
- Transformations of functional forms and OLS application – estimation of multi pleregression model-hypothesis testing
- Testing and correcting specification errors
- Testing and managing Multi collinearity
- Testing and managing heteroscedasticity
- Testing and managing auto correlation
- Estimation of regressions with dummy variables
- Estimation of regression with limited dependent variable

- Identification of equations in simultaneous equation systems

References

- GUJARATI, DAMODAR, *Basic Econometrics*, McGraw-Hill Company
- JAMES H. STOCK AND MARK W. WATSON: *Introduction to Econometrics*, Pearson Education

ABM 602 RESEARCH METHODS – I (2+1)

Objective

The objective of the course is to enable research scholars in developing the knowledge and skills required to specify, evaluate and utilise different types of unstructured and semi-unstructured information. They are required to develop competence in problem formulation, hypothesis generation and method of carrying scientific research in situations where research work plays a critical role. The course is practical in nature and students are expected to learn by doing live projects and studying the latest researches in different fields related to agri business.

Theory

Block I: Overview of Research Methodology

Unit 1: Translating problems to research issues: Selection of qualitative vs quantitative research definitions, objectives, research methodologies rationale, sample/sources of data, data collection techniques, Questionnaire designing: use of measurement and scaling techniques, reliability testing.

Unit 2: Fieldwork: Data collection, gaining access and entry, ethical considerations, identifying key informants, validation and evaluation of fieldwork, data preparation, field notes and recording

Unit 3: Hypothesis Development and Theoretical Modelling. Business Analytics, Business Intelligence,

Block II :Introduction to Business Analytics

Unit 1: Types of Business Analytics, Introduction to predictive modelling/analytics. Linear programming, Contemporary applications of marketing research

Practical

Identification and segmentation of research problems, framing of objectives and hypothesis, data sourcing, formulation of questionnaire, developing scales of measurement and reliability testing.

Sampling design for data collection, identification and sourcing data from key informants, data preparation. Survey documentation, Descriptive, predictive and prescriptive analysis (sale price and inventory optimization models).

Structuring linear programming models and contemporary applications.

References

- NARESH K. MALHOTRA, 2019, Marketing Research – An Applied Orientation, Pearson Education, 7th edition.
- COHEN L, LAWRENCE M AND MORRISON K. 2005. *Research Methods in Education* (5th edition). Oxford: Oxford University Press.
- DENSCOMBES M. 2010. *The Good Research Guide: For small-scale social research projects*. Maiden-Read: Open University Press.
- DORNYEI Z. 2007. *Research Methods in Applied Linguistics*. Oxford: Oxford University Press.
- KOTHARI CR. 1980. *Research Methodology: Research and Techniques*, New Delhi: New Age International Publishers.
- KUMAR R. 2011. *Research Methodology: a step-by-step guide for beginners* (3rd edition).
- SINGH YK. 2006. *Fundamental of Research Methodology and Statistics*. New International (P) Limited, Publishers, New Delhi.

ABM 603 AGRI INPUT AND OUTPUT MARKETING (2+1)

Objective

Agricultural Input & Output marketing is a dynamic and competitive field where lot is to be done looking to the gap in technology existing and possible. Changes are taking place in manifolds ranging from farming practices to trading in domestic and international markets. Presence of private players, infrastructure development, impact on prices, concept of e mandi etc are becoming more important to understand in current scenario. Scholars will also study the researches and articles to understand interesting changes going on in this field.

Theory

Block I: Introduction to Agri Input and Out Marketing Environment

Unit 1: Agriculture input and output marketing environment-Current status, trends, market structure, infrastructure, competition, Government intervention in agricultural inputs and outputs marketing.

Unit 2: Buyers/users behavior, Market Segmentation, Product and Pricing, Promotion and advancement in promotional strategies, Marketing Channels for different agri inputs and outputs.

Block II: Evaluation of Marketing Costs and Efficiencies

Unit 1: Evaluation of marketing costs and efficiencies, WTO and Indian Agriculture, Case Studies- Competitive marketing strategies and advancements in agricultural marketing, International agri marketing practices.

Practical

Analysis of market structure, Exercise and case study discussion on market segmentation, Exercise on different pricing methods and strategies, Exercise and case study discussion on advertising and sales promotion, Identification of marketing channels and analysis of price spread, Exercise on evaluation of marketing efficiency.

References

- BROADWAY AC & BROADWAY ARIF A. 2016. A Text Book of Agri-Business Management. Kalyani Pub.
- ACHARYA SS & AGARWAL NL. 2019. Agricultural Marketing in India. 4th Ed. Oxford & IBH.
- PINGALI VENUGOPAL & RAM KAUNDINYA. 2014. Agri-input Marketing in India. SAGE Pub.

- MAHAPATRA. S. Management of Agricultural Inputs, NIPA Publishers.
- SEETHARAMAN S.P. Agricultural Input Marketing, Oxford & IBH Pub. Co.
- KRISHNAMACHARYULU C.S.G. Rural Marketing: Text and Cases, Pearson Education India.
- RICHARD.L.KOHLS & JOSEPH. N. UHL. Marketing of Agricultural Products. Pearson Pub.

ABM 604 RESEARCH METHODS- II (2+1)

Objective

Once the students are equipped with the information required for interpretive research, RM II will train the students with advanced analytical tools and their uses.

Theory

Block I: Hypothesis Testing

Unit 1: Hypothesis testing, Analysis of variance and covariance, Correlation and regression, Discriminant and Logit analysis, Factor analysis, Cluster analysis, Multidimensional scaling and conjoint analysis.

Block II: Data Mining

Unit 1: Data Mining, Data Mining Methods—Data Dredging, Data Fishing, Data Snooping and Process Mining—Business Process Discovery, Conformance Checking and Model Enhancement. Arena Modelling.

Block III: Applications of Statistical Software

Unit 1: Applications of Statistical Softwares like SAS, Modelling with statistical softwares. Report preparation and presentation, International Marketing Research.

V: Practical

Data analysis using qualitative and quantitative univariate techniques and multivariate analysis by application of Discriminant and

Logit analysis, Factor analysis, Cluster analysis, Multidimensional scaling and conjoint analysis.

Data dredging and snooping

Business process discovery

Arena simulation modelling.

References

- COHEN L, LAWRENCE M AND MORRISON K. 2005. *Research Methods in Education* (5th edition).Oxford: Oxford University Press.
- DENSCOMBES M. 2010. *The Good Research Guide: For small-scale social research projects*. Maiden-Read: Open University Press.
- DORNYEI Z. 2007. *Research Methods in Applied Linguistics*. Oxford: Oxford University Press.
- KOTHARI CR. 1980. *Research Methodology: Research and Techniques*, New Delhi: New Age International Publishers.
- KUMAR R. 2011. *Research Methodology: a step-by-step guide for beginners* (3rd edition).
- SINGH YK. 2006. *Fundamental of Research Methodology and Statistics*. New International (P) Limited, Publishers, New Delhi.

ABM 605 NATURAL RESOURCE MANAGEMENT (2+0)

Objective

The course on Natural Resource Management will provide in depth knowledge to the participants to look for ways to make responsible natural resource management decisions which will have an impact on all stakeholders.

Theory

Block I: Introduction to Natural Resources

Unit-1 Natural resources: Types and classification of natural resource, concept of Economic value, relevance of environmental economics, ecosystems services, direct and indirect economic benefit from – forest ecosystems, mountain ecosystems, mineral and water resources, ecotourism. Valuation and accounting: Supply and demand, conservation and management, cost/ benefit analysis, methods of costing, cost criteria, evaluating alternative projects, operational vs. total costs, determining benefiting vs. comprehensive stakeholders Application of resource accounting. Methods of pricing resources- example forest and mineral resources.

Unit-2: Economic resource theory and applications: Concept of CPR, open access, Ecological economics-methodology, economic valuation of non-market benefits, environmental accounting, population resources and the environment, command and control vs. emission trading, emission trading vs. exposure trading, hotelling principle, future strategies for mineral resources.

Block II: Overview of Natural Resource Management

Unit-1: Natural Resource Management: Initial concept of market and marketing, NRM sectors product marketing and their roles, promoting NRM products- NTFPs, livestock, watershed, fisheries, agriculture and medicinal plants and ecotourism, Role of national and international organizations in the promotion of sustainable natural resource use and management.

Unit 2: Concept of environmental services: Definitions, ecotourism, alternative examples, development of ecotourism in India and outside. Threats due to large scale ecotourism. Payment for Ecosystem Services, the ecotourism dilemmas: High value may also be high impact, bulk ecotourism and problems, stakeholder challenges, tourist carrying capacity. Ecotourism Policy and practices, national policy frame work, example – Madhya Pradesh & Uttarakhand State case. Successful ecotourism initiative, Criteria and Indicators for sustainable Ecotourism.

References

- BARBER E. 1989. *Economics: Natural Resources Scarcity and Development*. Earth scan.
- HARRIS JM. 2006. *Environmental and Natural Resource Economics: A Contemporary Approach*, 2nd edition. Houghton Mifflin

- FIELD BARRY C. 2008. *Natural Resource Economics: An Introduction*. Waveland Press.
- HONEY MARTHA. 2008. Ecotourism and Sustainable Development: Who Owns Paradise? 2nd edition. Island Press. 2. Seema Bhat & Syed Liyakhat 2008. Ecotourism Development in India: Communities, Capital and Conservation published by CEE, Ahmedabad

ABM 606 KNOWLEDGE MANAGEMENT (2+0)

Objective

The objective of the course is to provide the basics of the emerging area of Knowledge Management to students. This course throws light on few important concepts as Knowledge management and Information Technology, Knowledge process, etc.

Theory

Block I: Introduction to Knowledge Management

Unit 1: The Knowledge Economy: Leveraging Knowledge, Data-Information knowledge- Wisdom relationship, organizational knowledge, characteristics and components of organizational knowledge –Building knowledge societies- Measures for meeting the challenges of implementing, KM programmes.

Unit 2: Knowledge Management and Information Technology: Role Information Technology in Knowledge Management Systems, Knowledge Management tools, Creative effective Knowledge Management Systems through Information Technology, ERP and BPR, Data Warehousing and Data Mining.

Block II: Future of Knowledge Management and Industry Perspective

Unit 1: Future of Knowledge Management and Industry perspective: Companies on the road to knowledge management, Knowledge Management in Manufacturing and service industry, challenges and future of Knowledge Management.

Unit 2: The Knowledge Process: Universal appeal, Stages of KM Process, Knowledge Capital vs physical capital, Customer Relationship Management, Business Ethics And KM, The Promise of Internet and the Imperatives of the new age.

Unit 3: Implementation of Knowledge Management: Discussion on Roadblocks to success, Business Intelligence and Internet platforms, web Portals, Information Architecture: A three-way Balancing Act, KM, the Indian experience, Net Banking in India. –Role of knowledge Management in Organisational Restructuring. -The Mystique of a Learning Organisation.

References

- MATTISON: *Web Warehousing and Knowledge Management*, Tata McGraw-Hill, 2009
- BECERRA FERNANDEZ: *Knowledge management: An Evolutionary view*, PHI, 2009
- FERNANDO: *Knowledge Management*, Pearson, 2009
- B. RATHAN REDDY: *Knowledge management*, Himalaya, 2009
- TAPAN K PANDA: *Knowledge Management*, Excel, 2009.
- BARNES: *Knowledge Management systems*, Cengage, 2009.
- TIWANA: *The Knowledge Management tool kit*, 2/e, Pearson Education, 2009.
- WARIER: *Knowledge Management*, Vikas Publishing House, 2009
- SISLOP: *Knowledge Management*, Oxford University Press, New Delhi, 2009
- DEBOWSKI: *Knowledge Management*, Wiley Student Edition, Wiley India, 2007

ABM 607 VALUE-CHAIN MANAGEMENT IN AGRIBUSINESS (2+0)

Objective

To recognize the characteristics of Global Food Systems, the multiple variable simpacting Global Food Systems, to identify value chain thinking and how it differs from supply chain thinking, the characteristics of agri-food markets, what influences their supply and demand, and what sets them apart from other markets, the roleplayed by external factors such as population and income growth, globalization, climate change, technology, and international trade in global food systems, agribusiness and value chains, to recognize the role the consumer plays in the food system, markets, and value chains

Theory

Block I: Global Food Systems and Value-Chains

Unit 1: Introduction to global food systems; characteristics of global food systems; current status and trends in global food systems; variables impacting global food systems; role of external factors (for example, population and income growth, globalization, climate change, technology and international trade) on performance of global food systems.

Unit 2: Agribusiness and value chains; Value chain interventions within the agri-food system; Value chain thinking versus supply chain thinking; characteristics of food value chains, food value chain model building; sustainable food value chain development and green food value chain development.

Block II: Agribusiness Market Dynamics

Unit 1: Characteristics of agri-food markets, factors influencing supply and demand in agri-food markets, unique features of agri-food markets; role of external factors, such as population and income growth, globalization, climate change, technology and international trade on agri-food markets; agribusiness sub sector analysis, global agribusiness hubs.

Block III: The Role of Consumer

Unit 1: Consumers role in the food system, markets and value chains; identification of consumer characteristics, trends and behaviours that influence food value chains; techniques used in market and consumer research to better understand consumer behaviour.

References

- ACHARYA SS AND AGARWAL NL. 2011. *Agricultural marketing in India*. Oxford and IBH.

- ALTEKAR RV. 2006. *Supply Chain Management: Concepts and Cases*. PHI
- CHOPRA S, MEINDL P AND KALRA DV. 2016. *Supply chain management: Strategy, Planning, and Operation*, Pearson Education India
- MOHANTY RP. 2010. *Indian Case studies in Supply Chain Management and other Learning Resources*. Oxford.
- CHANDRASEKARAN N. 2010. *Supply Chain Management: Process, system and Practice*. Oxford.
- SINGH SUKHPAL. *Organic Produce Supply Chains in India-organisation and governance*. Allied Publ.

ABM 608 AGRI ENTREPRENEURSHIP AND CORPORATE GOVERNANCE (2+0)

Objective

The course aims to make students understand the nature of entrepreneurship, and acquaint the students with challenges of starting new ventures and enable then to investigate, understand and internalize the process of setting up a business. Objective is also to enlighten them with the importance of Corporate Good Governance and Business Ethics.

Block I: Agri Entrepreneurship and Feasibility Studies

Unit I: Nature of Entrepreneurship: Concept, knowledge, skills requirement and functions; characteristic of successful entrepreneurs; ; scenario in India and Abroad, entrepreneurship process; factors impacting emergence of entrepreneurship; managerial vs. entrepreneurial approach and emergence of entrepreneurship, Risk

Reduction strategies

Unit 2: Starting the venture: generating business idea – sources of new ideas, methods of generating ideas, SWOT Analysis, environmental scanning, competitor and industry analysis; feasibility study – market feasibility, technical/operational feasibility, financial feasibility; drawing business plan; preparing project report; presenting business plan to investors.

Unit 3: Functional plans: marketing plan – marketing research for the new venture, steps in preparing marketing plan, contingency planning; organizational plan – form of ownership, designing organization structure, job design, manpower planning; Financial plan – cash budget, working capital, proforma income statement, proforma cash flow, proforma balance sheet, break even analysis.

Unit 4: Sources of finance: debt or equity financing, commercial banks, venture capital; financial institutions supporting entrepreneurs, Government Grants and Subsidies, Entrepreneurship Promotion Schemes of Department of Industries (DIC), KVIC, SIDBI, NABARD, NSIC, APSFC, IFCI and IDBI etc.; legal issues – intellectual property rights patents, trademarks, copy rights, trade secrets, licensing; franchising.

Block 2: Introduction to Business Ethics and Corporate Governance

Unit 1: Necessity for Business Ethics- Salient Issues in Ethics and Commerce Shadow Economy – Basic Principles in Ethics –Corporate Climate and corporate climate audits – Political Issues – Nature and theory of Ethics, Corporate Governance- Historical perspective and issues of Corporate Governance –Corporate Governance mechanisms – Corporate Governance Models, – The confederation of Indian Industry's initiative.; Corporate Social Responsibility.

References

- ROBERT HISRICH MICHAEL PETERS Dean Shepherd Entrepreneurship 10th Ed 2016 by McGraw- Hill Education
- VASANTH DESAI: *Entrepreneurship*, HPH, 2011.
- DAVID MARTIN: *Corporate Governance*, Viva, 2010.
- NANDAN H: *Fundamentals of Entrepreneurship*, PHI, 2013.
- Barringer: *Entrepreneurship*, Pearson, 2015.
- RK MISHRA, GITARANI: *Corporate Governance*, Excel, 2012.
- V. BALACHANDRAN AND V. CHANDRASEKARAN: *Corporate Governance & Social Responsibility*, PHI, 2009.
- A.C. FERNANDO: *Business Ethics*, Pearson, 2009.
- LAURA P HARTMAN AND ABHA CHATTERJEE: *Business Ethics*, TMH, 2009.

- TRIPAT KAUR: *Values and Ethics in Management*, 2/e, Paragon International, 2009.

ABM 609 INTERNATIONAL FOOD AND AGRI BUSINESS (2+0)

Objective

The objective of the paper is to acquaint the students with the fundamentals of international business, its environment and complexities. The paper provides exposure to multiple dimensions of the field and imparts international perspective to business decisions.

Block I: Global Trends in International Trade

Unit 1: Global trends in international trade and finance; dimensions and modes of IB; structure of IB environment; risk in IB; organizational structure for IB; world trading system and impact of WTO; exchange rate systems; global financial system; barriers to IB; international business information and communication. Nature of international business. Scope and stages of internalisation. International business environment.

Unit 2: Foreign market entry strategies; country evaluation and selection; factors affecting foreign investment decisions; impact of FDI on home and host countries; types and motives for foreign collaboration; control mechanisms in IB. Multinational Corporations (MNCs) and factors contributing their growth. Organisational design and structure of MNCs.

Block II: Global Manufacturing and Material Management

Unit 1: Decisions concerning global manufacturing and material management; outsourcing factors; managing global supply chain; International product life cycle, product and branding decisions; managing distribution channels; international promotion mix and pricing decisions; counter trade practices; mechanism of international trade transactions. EXIM policy of India. Export costing and pricing, Export procedures and export documentation. Export assistance and incentives in India. Globalisation of markets, production, investment and technology, advantages and disadvantages of globalisation with special reference to India. Identification of important agricultural products with international importance.

References

- PORTER M. 1990. The Competitive Advantage of Nations, The Free Press, New York
- CETEORA PR. AND GRAHAM JL. 2002. International Marketing. Tata McGraw Hill, New Delhi.
- RAO PS. 2008. International Business: Text and cases. Himalaya Publishing House.
- JOSHI RM. 2011. International Business. Oxford University Press.
- HILL CWL AND JAIN AK. 2010. International Business: Competing in the Global Marketplace. Tata McGraw Hill Education Private Limited.
- SALVATORE D. 2014. International Economics: Trade and Finance. B.B. Press. Noida.
- VENKATESH CK, MATHAPATHI K AND GIRISH S. 2015. International Business. Kalyani Publishers.
- MANNUR HG. 2018. International Economics. Vikas Publishing House Pvt Ltd.

ABM 610 COMMUNICATION FOR MANAGEMENT TEACHERS (2+0)

Objective

Communication in management education is not limited to classroom teaching. There are lot of innovative techniques to make teaching and learning interesting, practical and effective. There are various researches are done for methodological and effectiveness aspects. This course will be dealt understanding all the methods of communication for management teaching in learning by doing method and presenting the various researches done in this field.

Block I: Management Education

Unit 1: Management Education: Concept -Functions - Evolution of Management Education-Trends and Challenges - Action gaps in Management Education - Skills gap in Management Education -Recent developments.

Block II: Theory and Techniques of Communication in Management

Unit 1: Communication: Concept- Theories of organizational communication-Active listening- Group Communication-Language process- Presentation on readings- recorded and graded: Oral presentation & computer assisted presentations.

Unit 2: Theory and Techniques: Didacticism- Group work & discussion method- Experiential Learning- Meaning-Four Stages of Experiential Learning- Models- Methods- Principles & Practices - Emotional perspective in teaching-Emotions, learning and instruction.

Unit 3: Learning in management education: Experiential learning, Action Learning- Group learning- Simulation and games-Role Play-Teaching and learning through Electronic Media.

Block III: Case Teaching and Writing

Unit 1: Case method of teaching- Learning with cases-**The Case Difficulty Cube and the Three Stage Learning Process-Individual Preparation-Small Group Discussion-Large .**

Group Discussion- Teaching with Cases- Couse Planning-Preparation for class- Classroom Process- Class Evaluation- Case variations - Case Study as a Research Method- Selecting a Design - Gathering Information from Interviews, Observations and documents-Interpreting the Information- Reporting Findings- Guide to Writing Teaching Notes. - Writing a research article.

References

- NIRAJ KUMAR – Communication and Management, Gyan Publishing House
- Effective Communication (Essential Managers) by DK, 2022

Ph.D. in Agricultural Economics

Course Code	Course Title	Credit Hours
AEC 601	Advanced Micro Economic Analysis	2 (1+1)
AEC 602	Advanced Macro Economic Analysis	2 (2+0)
AEC 603	Advanced Econometrics	3 (2+1)
AEC 604	Advanced Production Economics	3 (2+1)
AEC 605	Operations Research	3 (2+1)
AEC 606	Advanced Agricultural Marketing and Price Analysis	3 (2+1)
AEC 607	Quantitative Development Policy Analysis	2 (1+1)
AEC 608	Natural Resource Management	3 (2+1)
AEC 609	Environmental Economics	3 (2+1)
	Total	**24 (16+8)**
AEC 680	Qualifying Examination	3 (0+3)
AEC 681	Seminar -I	1 (0+1)
AEC 682	Seminar - II	1 (0+1)
AEC 683	Teaching Assistantship -I	1 (0+1)
AEC 684	Teaching Assistantship - II	1 (0+1)
AEC 691	Research -I	18 (0+18)
AEC 692	Research -II	18 (0+18)
AEC 693	Research -III	18 (0+18)
AEC 694	Research -IV	18 (0+18)

AEC 601 ADVANCED MICRO ECONOMIC ANALYSIS (1+1)

Objective

To gain fundamental understanding of consumer behavior, producer's strategy, market structure through which transactions take place and human and firms interact. Develop foundation of scarce resource allocation for optimum results.

Theory

Block 1- Consumer Theory

Unit 1: Consumer Theory

Theory of consumer behavior – Duality in consumer theory – expenditure function and indirect utility function – Measurement of Income Effect and Substitution Effect. Measurement of Changes in Consumers' Welfare – Consumer's Surplus, Compensating Variation and Equivalent Variation – Dynamic versions of demand functions – Integrability of demand functions. Demand Models – Linear Expenditure System, Almost Ideal Demand System. Applications of consumer theory – Household model and time allocation – Labour supply decisions by households.

Block 2- Market and General Equilibrium

Unit 1: Market

Perfect competition – Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly –Cournot model, Chamberlin model, Stackleberg solution.

Unit 2: General Equilibrium

General equilibrium theory – Conceptual overview – General equilibrium conditions with Production and Consumption. Existence, Uniqueness and Stability of general competitive equilibrium. Walrasian general equilibrium – Mathematical derivation of conditions for general equilibrium.

Block 3- Market Failure and Welfare

Unit 1: Market failure

Market failure – Incomplete markets – Asymmetric information – Principal–Agent problem, adverse selection and moral hazard.

Externalities – Network externalities, Public goods – Optimal provision of public goods.

Unit 2: Welfare Economics

Welfare Economics – Concepts, problems, approaches and limitations of Welfare Economics, Pareto conditions of maximum welfare – Criteria for social welfare – Social Welfare functions, Social versus Private costs and benefits.

Practical

- Problems in consumer utility maximization
- Estimation of income and substitution effects;
- Estimation and comparison of Consumer's surplus, equivalent variation and Compensating variation.
- Estimation of demand models – Derivation and estimation of labour supply equations from household models comparative static analysis in consumption.
- Advanced problem solving in price determination under perfect competition, monopoly, oligopoly and monopolistic competition.
- Game theory models.
- Problems solving in General Equilibrium Theory and Welfare Economics.
- Problems in public goods provision.

References

- HENDERSON JM AND QUANDT RE. *Microeconomic Theory: A Mathematical Approach* Tata Mc Graw Hill Publishing Co Ltd
- KOUTSOYIANNIS A. *Modern Micro Economics.* Macmillan Press Ltd
- FERGUSON AND GOULD. *Micro Economic Theory.* Richard DErw in Inc USA

AEC 602 ADVANCED MACRO ECONOMIC ANALYSIS (2+0)

Objective

To understand the functioning of national economy, its history and models. The policies governing the modern economic system and concerned institutions.

Theory

Block 1- Introduction

Unit 1: Overview

Conceptual framework - Classical, Keynesian, Neo-Classical, and Neo-Keynesian macroeconomics; Review of Keynes-Classical Synthesis; Aggregate Demand and Supply in the closed economy with fixed and variable price level- determination of wage, prices, output and employment.

Block 2- Economic Models

Unit 1: Open Economy Models

Exchange rate determination; purchasing power parity; asset market approach; Short-run open economy models; Mundell-Fleming model- exchange rate regime: perfect capital mobility under fixed and flexible exchange rate; effectiveness of fiscal policy and monetary policy; Dornbusch's overshooting model; monetary approach to balance of payments; international financial markets.

Unit 2: Dynamic Macroeconomic Models

Introduction to dynamic macroeconomic Models; Dynamic aggregate demand and supply – short and long term equilibrium- rational expectations approach

Block 3: Business Cycle and Policies

Unit 1: Business Cycles

Business cycle and its alternative equilibrium model, Stability analysis Economics of Great Events-Depression, Hyperinflation and Deficits; Advances in Business Cycle Theory; Real Business Cycles &

Neo-Keynesian Economics

Unit 2: Macroeconomic Polices

Monetary policy - Design of Monetary Policy; Inflation Targeting, Fiscal Policy - Effectiveness and problems.

Government Budget Constraint: The Arithmetic of Deficits and Debt, Current versus Future Taxes, the Evolution of Debt-to-GDP Ratio; Public Borrowing-Internal and external aid, Deficit financing, Development Financing; BOP & Adjustment Policies - Foreign Exchange Policy -International macro-economic policies, IMF, IBRD, Central banking, UNCTAD.

References

- HEIBROKER RL. Understanding Macro Economics.
- MEHTA JK. Macro Economics.
- EDGEM AND MR. MACRO - Economics: Theory & Policy.
- DAVID' W PEARCE. The dictionary of modern Economics.
- ALLENRGD.1968. Macro Economic Theory: A Mathematical Treatment. London: Macmillan.
- STANLAKE GF. Macro–Economics: An Introduction. Longman, London.
- MITHAI DM.1981. Macro–Economics: Analysis and Policy. Oxford and IBH, NewDelhi.
- HICKS JR Critical Essays in Monetary Theory.
- NAWIYN WT. Theory of Money.

AEC 603 ADVANCED ECONOMETRICS (2+1)

Objective

The course aims at providing the knowledge and command over analysis of data collected to get the desired result. Train the student in use of econometric models.

Theory

Block 1: Concepts

Unit 1: Review

Introduction to Econometrics and stages in econometric model building. Review of classical regression model – review of hypothesis testing – restrictions on parameters – single equation techniques. Endogeneity in linear regression models.

Block 2: Least Squares and Dummy Variables

Unit 1: Concept of least squares

Ordinary least squares – weighted least squares - generalized least squares – method of principal components – instrumental variables method - maximum Likelihood method - errors in variables, non-linearity and specification tests – non Spherical error terms. Flexible functional forms-Translog, Normalized quadratic- features, properties and estimation.

Unit 2: Dummy Variable

Dummy variables- Qualitative and truncated dependent variables – limited dependent variables –LPM, probit, Poisson and logit models, their multinomial extensions, Trinity of Classical Testing with applications, Binary Choice and Count Data. Maximum Likelihood Estimation.

Block 3: Econometric Models

Unit 1: Models and their extensions

Autoregressive distributed lag models – panel data fixed and random effects models and their extensions.

Unit 2: Simultaneous equation models

Simultaneous equation methods- identification, estimation by indirect least squares 2SLS, PIML, SURE, 3SLS Instrumental Variables Approach.

Instrumental Variables (IV) Estimator. Finite-sample and Asymptotic Properties of the IV Estimator. Choice of Instruments.

Practical

Fitting selected continuous and discrete distributions and their use in econometrics- Normal, Gamma, Beta, Lognormal, Weibull, binomial, negative binommical, etc. Estimation of multiple regression model - GLS estimation methods – testing misspecification errors – Testing and Managing multi co linearity, heteroscedasticity and autocorrelation – estimation of flexible functional form like translog and normalized quadratic -estimation of LPM, Logit, Poisson and Probit models - comparing two regressions - Chow test - estimation of distributed lag models – panel data random and fixed effects models - Indirect least squares 2SLS, SURE, 3SLS, estimation of Simultaneous equation models.

References

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- JOHNSTON J AND DINARDO J. 2000. Econometric Methods. McGraw-Hill.
- KOUTSEYIANIS A. 1997. Theory of Econometrics. Barner& Noble.
- VERBEEK, MARNO, A Guide to Modern Econometrics, Johns Wiley and Sons
- DAMODAR GUJARATI (Author),Dawn Porter (Author), Basic Econometrics

AEC 604 ADVANCED PRODUCTION ECONOMICS (2+1)

Objective

The course deals with the concept of advanced production economics. The exposition would be mathematically oriented. The course would also cover the analysis of production functions, its interpretation, decision making with multiple input use, factors haring and decision making under risk and uncertainty.

Theory

Block 1: Production process

Unit 1: Production Process

Agricultural Production process – Relationship between farm planning and production economics-scope of agricultural production and planning-methods/ procedures in agro-economic research and planning.

Block 2: Production Function

Unit 1: Production Functions and characteristics

Production functions, components, assumptions, properties and their economic interpretation - Concepts of homogeneity, homotheticity,, APP, MPP, elasticities of substitution and their economic relevance – Production relations – optimality- Commonly used functional forms, nature, properties, limitations, estimation and interpretation - linear, Spillman - Cobb Douglas, quadratic, multiplicative (power) functional forms - Translog, and transcendental functional forms - CES, production functional forms-Conceptual and empirical issues in specification, estimation and application of production functions- Analytical approaches to economic optimum - Economic optimum – determination of economic optimum with constant and varying input and output prices - Economic optimum with production function analysis - input use behavior.

Block 3: Dynamics of production process

Unit 1: Decision Making in Production

Decision making with multiple inputs and outputs – MRT and product relationship- cost of production and adjustment in output prices-single input and multiple product decisions- Multi input, and multi product production decisions - Decision making with no risk -Cost of wrong decisions - Cost curves – Principles and importance of duality theory - Correspondence of production, cost, and profit functions - Principles and derivation of demand and supply functions.

Unit 2: Technology, Efficiency and Risk Management

Technology, input use and factor shares -effect of technology on input use- decomposition analysis-factor shares-estimation methods-Economic efficiency in agricultural production – technical, allocative and economic efficiency – measurement -Yield gaps analysis – concepts and measurement - Risk and uncertainty in agriculture – incorporation of risk and uncertainty in decision making – risk and uncertainty and input use level-risk programming.

Unit 3: Programming

Simulation and programming techniques in agricultural production-Multiple Objective Programming (MOP) – Goal programming, Weighted sum and Compromise programming – applications.

Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations-Optimal product and input choice under multi input and output system-Estimation of factor shares from empirical functions estimated-Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology-Estimation of efficiency measures – Stochastic, probabilistic and deterministic frontier production functions-Risk programming – MOTAD-Quadratic programming- Simulation models for agricultural production decisions-Goal programming – Weighted, lexicographic and fuzzy goal programming-Compromise programming.

References

- BAUMOL WG.1973. *Economic theory and operations analysis*. Practice Hall of India Private Limited, New Dehli. 626p.
- GARDNER BL AND RAUSSER GC.2001. *Handbook of Agricultural Economics* Vol. I Agricultural Production. Elsevier
- HEADY EO. 1952. *Economics of Agricultural Production and resources use*. Practice Hall of India.
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AEC 605 OPERATIONS RESEARCH (2+1)

Objective

To gain elementary knowledge of solving problems and decision making for managing farming and organization in resource constraint in order to achieve the objective.

Theory

Block 1: Concepts

Unit 1: Concepts

Elementary concepts and objectives of Operations Research, Review of Linear programming - Assumptions & Methods, Non-linear programming problem - Quadratic programming, Goal Programming, Multi Objective Programming (MOP)

Block 2: Inventory and Models

Inventory control models, costs involved in Inventory management, types of inventory, Economic order quantity(EOQ) model, EOQ with price breaks. Waiting line models: Waiting line problem, Characteristics of a waiting line system, Single channel model, Project Scheduling-PERT and CPM, Crashing.

Unit 2: Models

Markov Chains, Sequencing, Replacement models, Transportation and Assignment problems.

Block 3: Decision Making

Unit 1: Decision Making and Game Theory

Decision making under risk and uncertainties, decision problem, maximax criterion, maximin criterion, minimax regret criterion, Laplace criterion, Pay off tables, Decision trees, Expected value of perfect information. Game Theory – Two-person Zero sum game, Simulation, Network Analysis- PERT & CPM.

Unit 2: Minimization of Total Absolute Deviation (MOTAD), Integer programming.

Practical

- Linear and Non-linear programming problem,
- Quadratic programming, Multi-Objective Programming- Goal Programming,
- Lexicographic, Weighted Sum, Determining economic order quantity, reorder levels of EOQ model. EOQ with price breaks
- Waiting line problem, Problems on Markov Chains, Sequencing and Replacement models.
- Formulating and solving transportation type problems, Assignment problems as a special type of transportation problem.
- Solving deterministic and probabilistic queuing models Structuring and solving decision trees for optimal decisions Game theory, Simulation, Developing network (PERT/CPM) diagrams and determining the critical path, Crashing.

References

- TAHAH A. *Operations Research: An Introduction*.
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- Gupta Pk And Hira Ds. *Operations Research*.
- SHARMA R. *Operations Research*
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- Greene Wh. 2002. *Econometric Analysis*. Pearson Education.
- JOHNSTON J AND DINARDO J. 2000. *Econometric Methods*. Mc Graw-Hill.
- KOUTSEYIANIS A.1997. *Theory of Econometrics*. Barner & Noble.

AEC 606 ADVANCED AGRICULTURAL MARKETING AND PRICE ANALYSIS (2+1)

Objective

To impact adequate knowledge and analytical skills in the field of agricultural marketing and enhance expertise in improving the performance of the marketing institutions and the players in marketing of agricultural commodities. Learning outcome: After successful completion of this course, the student will be able to-Gain the knowledge of marketing and agricultural prices. Work out the interaction between different markets and analyses their working. Gain expertise in forecasting of price and build up market intelligence.

Theory

Block 1: Concepts

Unit 1: Agricultural Marketing

Insights Importance of market analysis in the agricultural system – functions of marketing, Market integration, types of marketing-advantages and disadvantages - quantitative estimation of arrivals and prices –the distinguishing characteristics and role of agricultural prices -data sources for agricultural products and prices - software's used in market analysis,

Block 2: Marketing Institutions and Dynamics

Unit 1: Institutions and their functions

Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency - public - private partnership - institutional arrangements. Successful case studies.

Unit 2: Market Dynamics

Multi market estimation, supply response models. Market integration and price transmission - supply / value chain management. GAP analysis. Current trends in information in the changing agri food system.

Block 3: Techniques

Unit 1: Commodity Marketing

Agricultural commodity marketing -spot and futures- marketing of derivatives, speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity markets-Regulatory mechanism of futures trading. Introduction to technical analysis of commodity prices.

Unit 2: Models for Analysis

Structure, conduct and performance of markets. Lag operators and difference equations; stationary and stochastic processes; Unit roots and co-integration; conditional heteroscedasticity: Unit root test. Vector Auto Regressive (VAR) and Vector Error Correction (VECM) models, Impulse Response Function (IRF).Price volatility-ARCH and GARCH models. ARIMA, Holt Winters, Exponential Weighted Average Models (EWA), Machine learning models of price forecasting. Stationarity, random walk determination -forecast evaluation; methods of forecasting. Price indices and econometric estimation and simulation.

Practical

1. Estimation of demand/ supply forecasting,
2. Supply chain/ value chain analysis for different commodities
3. Commodity models- multi market estimation- time series analysis
4. Market integration studies- price discovery price volatility estimation
5. Commodity price forecasting using econometric software's.
6. Technical analysis of commodity prices.

References

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- RHODESVJ.1978. *The Agricultural Marketing System*. Grid Pub. Ohio.
- KOHLS Marketing of Agriculture Products 9e Pearson.
- JOHN W GOODWIN, Agricultural Price Analysis and Forecasting.
- WALTER C LEBYS, Modelling and forecasting Primary Commodity Prices
- ADAM GRIMES , The Art and Science of Technical Analysis: Market Structure, Price Action, and Trading Strategies.

- WILEY TRADING CRAIG, PIRRONG, Commodity Price Dynamics: A Structural Approach Paperback

AEC 607 QUANTITATIVE DEVELOPMENT POLICY ANALYSIS (1+1)

Objective

To develop expertise in understanding the rationale behind development of policies. Conceptualization of equilibrium and working out the economic implications of development policy. Learning outcome: After the completion of the course, the student will be able to- Conceptualize policy framework. Get acquainted with analyzing the policy and workout corrective solutions

Theory

Block 1: Concepts

Unit 1: Policy Framework Policy framework – goals, value, beliefs and welfare maximization. Market – Policy and State – State vs. Market – Failure of Policy – Failure of Markets - Rationale for Government Intervention. Role of Quantitative Policy Analysis.

Block 2: Demand-supply and household behavior

Unit 1: Demand- Supply Analysis

Demand analysis for policymaking – Alternative approaches to demand analysis – Policy implications. Supply response – Alternative approaches to measurement of supply response – Nerlovi an models of supply response – Policy implications, Cost and profit function approaches of estimating supply response.

Unit 2: Household Behavior and models

Household behavior and policy analysis – Household models. Demand models like Almost Ideal Demand System (AIDS) models; features and estimation.

Block 3: Approaches to review policy and welfare

Unit 1: Multi-Pronged approach to policy review

Partial equilibrium analysis – Concept of reference prices – Price distortions – indicators and impact. Transaction costs – Implications for efficiency and productivity – Institutional solutions - Multi market approach to policy analysis.

Unit 2: General equilibrium and programming

Social Accounting Matrices and multipliers –– Computable General Equilibrium models to assess economy wide impact of policy changes. fuzzy goal programming- Compromise programming.

Practical

- Review of criteria for policy evaluation
- Estimation of price elasticity's of demand and supply.
- Review of estimation of complete demand systems
- Estimation of flexible functional forms- cost function and profit function.
- Review of Household models
- Specification and estimation of household models
- Partial equilibrium analysis
- Input–output table
- Social Accounting Matrix
- Construction of a SAM
- Computation of Multipliers
- Multi Market Analysis
- Review of Computable General Equilibrium Models.

References

- ELISABETH SADOULET AND ALAIN DE JANVRY, Quantitative Development Policy Analysis
- NICO HEERINK, HERMAN VAN KEULEN, MARIJKE KUIPER, Economic Policy and Sustainable Land Use: Recent Advances in Quantitative Analysis for Developing Countries, Springer

AEC 608 NATURAL RESOURCE MANAGEMENT (2+1)

Objective

Concept building on natural resources. Gaining expertise in economic aspect of natural resources and maintain a balance between economic gains and environment conservation. Learning outcome – After the completion of the course, the student will be able to-Understand the natural resources and methodizes to develop plans for their optimal use. Work out the economics of forest, fisheries and ground water. Be able to deal with the legal matters of the natural resources.

Theory

Block 1: Concepts

Unit 1: Concepts

Natural resources - definition - characteristics and classification. Stock dynamics of renewable and non-renewable resources. Equation of motion for renewable and non-renewable resources. Fundamental equation of renewable resources.

Block 2: Models and Management

Unit 1: Models for economic view of natural resources

Growth curves of fishery and forest resources. The role of time preference in natural resource use. Simple two-period model of optimal use of renewable and non-renewable resources. Advanced models of optimal resource use – Static Vs. dynamic efficiency in natural resource use Applications of dynamic programming and optimal control.

Unit 2: Management of water resources

Economics of groundwater use - optimal extraction of groundwater. Analytical and numerical solutions for optimal inter-temporal allocation of natural resources. Optimal harvesting of single rotation and multiple rotation forests. Optimal management of fishery.

Block 3: Regulations and planning

Unit 1: Property Rights

Property rights in natural resources and their implication for conservation and management of natural resources. Management of common property natural resources – Institutional arrangements for conservation and management of common pool fishery, groundwater and forestry resource.

Unit 2: Dynamics of resource economics

Resource scarcity – Natural resource degradation – Poverty and resource degradation – Natural resource accounting - Pricing and valuation of natural resources – Natural resources policy.

Practical

Practical Derivation of the fundamental equation of renewable resources-Estimation of growth curves and stock dynamics for fishery and forestry resources. Simple two period problem of optimal resource use – Numerical solution for simple two-period model of dynamic efficiency in natural resource extraction. Multi-period dynamic efficiency – Using Excel Solver in solving dynamic natural resource harvesting problems. Using analytical solution procedures for solving natural resource management problems – Optimal control.

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AEC 609 ENVIRONMENTAL ECONOMICS (2+1)

Objective

To understand the economic outcomes of environmental degradation. Make students proficient in decision making regarding environment protection, resource use, and conservation policy.

Theory

Block 1: Overview

Unit 1: Overview of Environmental Economics

Environmental pollution as a consequence of market failure - Causes and consequences of market failure - Externalities - Public goods and externalities -Economics of pollution – Optimum pollution under market imperfection and uncertainty- Private vs. Social cost of environmental pollution – Property rights, environment and development – Theory of environmental policy.

Block 2: Assessment and Development Dynamics

Unit 1: Economic assessment

Environmental cost benefit analysis - Environmental impact assessment techniques Non-market valuation of environmental resources (WTP / WTA) - Environment, market and social welfare function and Pareto–optimality.

Unit 2: Developmental aspects

Economic growth and environmental cost - Growth oriented economic policies and their environmental impacts - Population and environmental quality - poverty and environmental degradation – Sustainable development – Indicators of sustainable development – Issues in sustainable development.

Block 3: Regulations and Issues

Unit 1: Accounting, Policies and Regulation

Environment, ecology and environmental accounting - Environmental pollution with respect to water and air - Land and forest resources related environmental pollution - Coastal externalities - Urbanization and environment - Basic approaches to environmental policy (Tax, subsidy, pollution permits, etc.) Green taxes - Political economy of environmental regulation and management.

Unit 2: Environmental Issues

Trans boundary environmental problems - Economics of global warming, climate change and emission trading - Environment, international trade and development.

Practical

- Contemporary global environmental global environmental issues, movement, policies, programmes, laws and other regulatory mechanisms
- Criteria for evaluating the environment related projects and review of Environmental Impact Assessment (EIA) techniques
- Recreation demand models of environmental valuation
- Contingent valuation techniques
- Environmental Resource Accounting Techniques
- Discussion on the techniques dealing with air pollution and review of case studies on air pollution and its impacts - forest environment and wild life conservation
- Green GDP and Green house insurance
- Practical considerations and comparison of instruments of environmental policy
- Non-point source pollution control methodologies
- Environment in macroeconomic modeling
- Meta-analysis, economic valuation and environmental economics
- Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problems related to environment
- Input output analysis, technology and the environment
- Computable general equilibrium models for environmental economics and policy analysis.

References

- HACKETT SC.2001. Environmental and Natural Resource Economics: Theory, Policy and the Sustainable Society. ME. Sharpe, Armonk, NY.
- HARTWICK JM AND OLEWILER ND. 1998. The Economics of Natural Resource Use. 2nd Ed. Addison-Wesley Educational Publ
- KERR JM, MAROTHIA DK, KATAR SINGH, RAMASAMY CAND BENTLEY WR.1997. Natural Resource Economics: Theory and Applications in India. Oxford & IBH.
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Ph.D. in Agricultural Extension and Education

Course Code	Course Title	Credit Hours
AEE 601	Policy Engagement and Extension	3 (2+1)
AEE 602	Methodologies for Social and Behavioural Sciences	3 (2+1)
AEE 603	Technology Commercialization and Incubation	3 (2+1)
AEE 604	Educational Technology and Instructional Design	3 (2+1)
AEE 605	Risk Management and Climate Change Adaptation	3 (2+1)
AEE 606	Livelihood Development	2 (1+1)
AEE 607	Facilitation for People Centric Development	3 (2+1)
	Total	**20 (13+7)**
AEE 680	Qualifying Examination	3 (0+3)
AEE 681	Seminar -I	1 (0+1)
AEE 682	Seminar - II	1 (0+1)
AEE 683	Teaching Assistantship -I	1 (0+1)
AEE 684	Teaching Assistantship - II	1 (0+1)
AEE 691	Research -I	18 (0+18)
AEE 692	Research -II	18 (0+18)
AEE 693	Research -III	18 (0+18)
AEE 694	Research -IV	18 (0+18)

AEE 601 POLICY ENGAGEMENT AND EXTENSION (2+1)

Objective

To orient students on the importance of policies in shaping extension's performance, ways of generating policy relevant evidence to influence policies and to develop capacities for engaging with policy actors and the policy development process

Theory

Block 1: Why Policies Matter?

Unit 1: Understanding Policy

Why policies are important for extension? Role in providing structure, ensure funding and framework for providing functions-examples; Policy: definitions and types: Is policy a product or a process or both? Policies and institutions-How these influence defining organisational roles and performance in extension organizations-Role of policies in up scaling knowledge-Role of extension in influencing policies to enable innovation.

Unit 2: Policy Advocacy and Tools

Definition of advocacy, Approaches to policy advocacy-Advising, Media campaigning, Lobbying, Activism, Information Education Communication (IEC) and Behavior Change Communication (BCC); Advocacy for Rural Advisory Services (RAS); Policyadvocacy strategy

Unit 3: Policy Analysis

Explain the meaning and use of policy analysis in decision- making; Describe different types of policy analysis- empirical, evaluative or normative policy analysis, retrospective/ prospective policy analysis, predictive/prescriptive/descriptive policy analysis; How to do policy analysis? - understand the process of policy analysis, highlight the different methods and techniques used in policy analysis, doing ethical policy analysis; Tools for policy impact- research tools, context assessment tools, communication tools, policy influence tools

Unit 4: Policy Development Process

Policy development process: Who drives policy change?: National Governments, Donors, Civil Society-varied experiences: Understanding the environment and keyactors in policy space- problem identification-policy adoption, implementation and evaluation; stakeholder mapping, identifying opportunities and barriers, mobilising financial resources; Dealing with policy incoherence: identifying contradictions and challenges in policy implementation

Block 2: Using Evidence to Influence Policy Change

Unit 1: Influencing Policy Change

Generating evidence: Role of policy research; analyzing the usefulness and appropriateness of the evidence; Using evidence in policy advocacy; Understanding your audience: analyzing channels of influence; creating alliances; identifying policy champions; Defining goals and objectives; Developing advocacy messages: Policy papers, Policy briefs, good practice notes, *etc*.: Good practices in influencing policies Organising policy dialogues: Policy engagement strategy-Engaging with policymakers: GO and NGO experiences; Policy working groups; advisory panels; use of committees: Use of media including ICTs and social media for influencing policies.

Unit 2: Global Experience with Extension Policy

Extension policy in different countries: Explicit extension policy Vs extension as part of Agriculture Policy, Challenges in policy implementation: lack of capacities, financial resources, ownership, lack of stakeholder consultations: Strengthening capacities in extension to influence policies: Global Forum for Rural Advisory Services (GFRAS)'s efforts in strengthening extension policy advocacy: policy compendium, training modules, training for strengthening capacities to influence policies.

Practicals

- Analysis of country/state level agricultural/extension policy to understand the policy intentions from strengthening EAS
- Analysis of extension policy of other countries: policy intentions, processes adopted in development of the policy and mechanisms of policy implementation
- Interview key policy actors in EAS arena at the state/national level (eg: Director of Agriculture, Director of Extension in SAU, Chairman/Managing Director of Commodity Board. Member Agriculture, State Planning Board) to explore policy level challenges in EAS
- Identify what evidence policy makers look for from extension research? Is the evidence available? If so what form? (Reports, Briefs etc), If not, develop a plan
- Explore how different stakeholders influence policies (eg: policy advocacy of prominent NGOs, private sector and public sector) - What mechanisms and tools they use
- Identify policy level bottlenecks that constrain effective EAS delivery at the district level- Eg: Issues around linkages between

KVK and ATMA; inter-departmental collaboration; public private partnerships; joint action etc.

References

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- CRISP, MANAGE AND ICAR-ATARI.2016. *Training cum workshop on Strengthening Extension Policy Interface at MANAGE on 9-11th Nov, 2016 in collaboration with the CRISP & ICAR ATARI, Bangalore*. http://crispindia.org/index.php/events/
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AEE 602 METHODOLOGIES FOR SOCIAL AND BEHAVIOURAL SCIENCES (2+1)

Objective

To equip the scholars with advanced capacities in conducting systematic, objective and outcome oriented research by applying state-of-art methods and tools at every stage of research from planning to publishing and developing sound field focused extension strategies and models.

Theory

Block 1: Advanced Methods for Improving Quality of Research Data

Unit 1: Measurement Properties of Research Instruments

Measurement properties – Dimensionality, reliability and validity; Dimensionality– Unidimensionality and multidimensionality, Methods of assessing dimensionality, Formative and reflective constructs; Validity - Importance, Internal validity - face validity; content validity, Substantive Validity, Structural Validity; External validity- Convergent and Discriminant Validity, known-group validity, Criterion-Related Validity, Consequential Validity, nomological validity; Methods of assessing various forms of validities – Judges rating, Lawshe's Content Validity Ratio, Item-objective congruence index; latent variable method; Reliability - Internal consistency reliability– Split-Half, Cronbach alpha; Temporal Stability reliability - test-retest method; Interrater Consistency and Consensus – inter rater reliability and interrater agreement; Alternative Forms or parallel forms reliability – Reliability of difference-Factors Affecting the Validity and Reliability of Test Scores; Generalizability Theory

Unit 2: Threats to Data Quality

Errors and biases; Errors – Meaning and sources; Types - Sampling error, Non sampling or measurement error and Processing error – Meaning, causes; Effects of errors and biases on data quality; Bias in behavioural research – Meaning, causes, Types – Respondent and researcher biases; Methods of reducing errors and biases in surveys, questionnaires, personal interviews, focus groups and online methods

Block 2: Scales, Indexes and Tests

Unit 1: Scales, Indexes and Tests-1

Approaches to measurement and scale development - Classical test theory. Formative or index models, The C–OAR–SE approach and Item Response Theory; Item analysis in Classical test theory – item difficulty and item discrimination; Scoring performance in scales and tests – meaning, types and methods; Scale development strategies – deductive and empirical; Stimulus-centred scales – method of equally appearing intervals, paired comparison, Person scaling – Q methodology; Subject centre scales – The Likert scale and Semantic Differential

Unit 2: Scales, Indexes and Tests-2

Steps in constructing a multi-dimensional scale using confirmatory factor analysis,; Response scales - Guttman'sscalogram analysis and The Rasch method; Indexes

–Meaning, types, importance; Similarities and differences with scales, Methods of constructing indexes; Common indexes used in extension. Measurement invariance –Meaning, types, methods of assessing measurement invariance. Tests – meaning, types, importance; steps in conducting various tests – knowledge test

Block 3: Emerging Research Approaches and Designs

Unit 1: Qualitative Research Methods

Qualitative methods – Meaning; Types – Ethnography, Grounded theory, Phenomenology, Ecological psychology, Discourse Analysis; Observational research; Case study research – Sampling and sample size; Data collection methods – Indepth interviews, Focus groups, Direct observation, Record review; Content analysis; Unobtrusive Measures; Projective and semi-projective techniques; Selecting right qualitative method – Strengths and limitations of qualitative research; Analysis and interpretation of qualitative research data; Research synthesis – meaning, importance, methods; Systematic reviews and meta analysis – meaning, steps, and applications; Policy research

Unit 2: Emerging Approaches

Mixed methods research – meaning, purpose, types and applications; Participatory research – Meaning, importance, types, methods and tools and applications; Action research – Meaning, importance, Principles, Types, Steps in conducting action research, application in behavioural sciences. Social Network Analysis – Meaning, importance, types, steps in social network analysis, applications; Advanced methods of measuring perception and beliefs. Multi criteria decision making, analytical hierarchy approach

Block 4: Utilising Research Outputs

Unit 1: Publishing Research

Scholarly communication process; Research reports – Meaning, types, contents; Presentations – Meaning, types, principles of good presentation - Tell ’Em” and KISS ’Em” principles; Research publications – meaning, importance, types;

Guidelines for preparing research papers - Peer review process, citation styles; Open access publishing; Publishing in social media. Software in academic writing

Unit 2: Ethics in Extension Research

Ethics in conducting behavioural research; Human subject research – Meaning, history, and ethical guidelines; Ethical aspects of collecting and using Indigenous knowledge and farmers technologies; Ethical practices in publishing; Plagiarism – meaning, sources, Identifying and correcting plagiarism in a research paper using anti-plagiarism software

Practicals

- Practice in developing research instruments
- Methods of assessing measurement properties of research instruments - dimensionality, reliability and validity
- Hands-on exercise in minimising errors and biases

- Hands-on experience in constructing tests, scale and indexes
- Practice in summated scale development using confirmatory factor analysis
- Hands on experience in assessing measurement invariance
- Practicing and collecting data using participatory tools and techniques, analysing and interpreting qualitative data
- Hands-on experience in writing systematic review using meta-analysis
- Field practice in conducting action research
- Practical experience in writing research paper
- Hands on exercises using software for qualitative data analysis
- Practice in detecting and correcting plagiarism using software

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AEE 603 TECHNOLOGY COMMERCIALISATION AND INCUBATION (2+1)

Objective

To develop a critical understanding among extension students about how the technology commercialisation process is linked to IPR management and entrepreneurship development.

Theory

Block 1: Technology Commercialisation and the Modern Context

Unit 1: Basics of technology commercialisation

Technology - Definition, functions, process of technological advancement – invention, discovery, innovation and technology; types of innovation - Basic research, Breakthrough innovation, Disruptive Innovation and Sustaining Innovation; Technology transfer and commercialisation

Unit 2: Nature of Agricultural Technology

Agricultural technology – meaning, types; technology generation system; technology life cycle

Unit 3: Basics of Technology transfer and commercialisation

Technology transfer Vs Commercialisation; Technology commercialisation process – elements, models, systems and processes; Technology transfer model – research, disclosure, development and commercialisation

Block 2: Intellectual Property Resources (IPR) Management

Unit 1: Overview of Intellectual Property Resources

Introduction to IPR; Overview & Importance; Genesis; IPR in India and IPR abroad; Patents, copyrights, trademarks & trade secrets, geographical indication, industrial design; Emergence of IPR Regimes and Governance Frameworks - Trade-Related Aspects of Intellectual

Property Rights (TRIPS), Convention on Biological Diversity (CBD), Cartagena Protocol, International Union for Protection of New Plant Varieties (UPOV), and BIMSTEC.

Unit 2: Systems for Protecting IP

IPR protection laws and systems – National IPR Policy; and IPR laws; procedures for filing IP protection; Systems of IP protection and management in agricultural universities and research institutions and also by stakeholders

Unit 3: Management of IPR

Mechanisms of IPR Management – Institutional arrangement, IP Management processes – invention disclosure; IP portfolio management; Infringement management

Unit 4: Protection and Management of Biological Resources

Introduction; National Biodiversity Act (2002); Protection of Plant Varieties and Farmers Rights Act (2001); Guidelines for registration and transfer of biological resources; Farmers rights; Mechanisms of documenting/ collecting, protecting and commercialising farmers varieties and other biological resources; National Biodiversity Authority, PPVFRA and other agencies involved in management of biological resources in India. Access to Genetic Resources and Sharing of Benefits

Unit 5: Protection, Management and Commercialisation of Grassroot and Farmers Innovations, Traditional and Indigenous Knowledge

Traditional and Indigenous Knowledge, Grassroot and Farmers Innovations –Meaning, forms and importance; Systems of documentation, registration, protection and commercialisation. Documentation of traditional indigenous knowledge -Traditional Knowledge Digital Library (TKDL), Community Biodiversity Registers (CBRs), People's Biodiversity Registers (PBRs), Plant Biodiversity Register, and Honeybee Network.

Unit 6: Geographical Indications (GI) and Appellation of Origin

Geographical indications and appellation of origin – meaning, origin; Geographical Indications of Goods (Registration and Protection)

Act (1999); Documentation, registration and commercialisation of GI protected materials and processes.

Unit 7: Genetically Modified Organisms (GMO), Agriculture and Bio safety

The Global Concerns on Use of Genetically Modified Organisms in Food and Agriculture; The Cartagena Protocol on Bio-safety; Regulation of GMO in India - Recombinant DNA Advisory Committee (RDAC), Institutional Bio-safety Committee (IBSC), Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC), State Bio-safety Coordination Committee (SBCC) and District Level Committee (DLC). Laws and Acts for regulation of GMO - Guidelines for Research in Transgenic Plants, 1998; Seed Policy, 2002; Plant Quarantine Order, 2003; Regulation for Import of GM Products Under Foreign Trade Policy, 2006; National Environment Policy, 2006

Block 3: Technology Commercialisation

Unit 1: Technology Assessment and Refinement

Meaning; Importance; Approaches and methods of assessment and refinement of various technologies – stakeholder oriented approaches including participatory technology assessment and refinement; assessment and refinement of traditional and indigenous knowledge and grass root innovations

Unit 2: Technology Valuation

Returns to investment; IP Valuation-Oxford context, IP Valuation methods – Cost approach; Income approach - Discounted Cash Flow, Risk-Adjusted Net Present Value, Net Present Value with Monte Carlo Simulation and Real Options Theory; Market approach - Industry Standards Method, Rating/Ranking Method, Rules of Thumb Approach and Auction Method; Hybrid approaches; Royalty rate method

Unit 3: Technology Commercialisation Strategies

Meaning- approaches for technology commercialisation – technology scaling up, technology licensing, handholding, agripreneur development, technology business incubation

Unit 4: Scaling up of Technologies

Meaning, types and stages of technology scaling up; mechanisms

Unit 5: Technology Licensing

Meaning and types - Procedures of licensing, preparing licensing documents; Management of technology licensing process

Unit 6: Technology Takers and Entrepreneurship

Meaning; types of technology takers; Technology Taking as a Strategy; Types of entrepreneurship – agripreneurs, startups, small businesses, Producer Organizations, Self Help Groups, Clusters and other forms of entrepreneurship

Unit 7: Policy support for Technology Commercialisation and Entrepreneurship Development

Policy support for entrepreneurship development in India - National Policy on Skill Development and Entrepreneurship and other polices; Government of India Support for Innovation and Entrepreneurship – Startup India, Make in India, Digital India, Atal Innovation Mission and others; Entrepreneurship policy and schemes at different states of India; Organisations promoting entrepreneurship in India

Block 4: Technology Incubation

Unit 1: Basics of Technology Incubation

Meaning, functions and types; stakeholder oriented incubation process – Livelihood incubation, village incubators

Unit 2: Technology Incubation in India

System of technology incubation- incubation process; its effectiveness; Managing profit oriented and non-profit incubators; Schemes for promoting incubators in India

Block 5: Technology Promotion And Essential Skills For Technology Commercialisation

Unit 1: Technology Promotion

Technology promotion – meaning, types, business meetings, scientist-industry/ entrepreneur meets, technology conclave, business plan competition, farmers fairs, technology shows

Unit 2: Dealing with Entrepreneurs, Agripreneurs and Other Stakeholders

Business communication; Business Etiquette; business networking

Block 6: Emerging Approaches in Technology Commercialisation and Incubation

Unit 1: Technology Scouting

Technology Scouting and Innovations in technology incubation

Practicals

- Understanding the technology commercialisation process – Visit to Technology Commercialisation Unit of ICAR Institute/ Agricultural University
- Understanding the IPR protection practices – Visit to Patent Attorney office
- Hands-on experience in drafting IPR application – Patent/Copyright/ Trademark
- Understanding protection of biological resources including plant varieties – Visit to PPVFRA Branch office/ ICAR Institute or Agricultural University involved in plant variety protection
- Documenting Traditional and indigenous knowledge – Field experience in using various protocols of using traditional and indigenous knowledge
- Protecting unique local goods through Geographical Indications – Hands on experiences in documenting and registering Geographical indications
- Technology assessment/ validation of traditional and indigenous knowledge – QuIK and other methods
- Hands on experience in technology valuation
- Hands on experience in technology licensing process including drafting agreements
- Understanding the Technology Business Incubation – Visit to Agri Business Incubator or Technology Business incubator

- Hands on experience in planning and organising technology promotion events
- Hands on experience in various techniques in business communication and Business etiquette

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AEE 604 EDUCATIONAL TECHNOLOGY AND INSTRUCTIONAL DESIGN (2+1)

Objective

To develop the students to be knowledgeable, responsive and effective teachers committed to educate diverse group of learners, appreciate the role of technology in learning, integration into instructional designs and prepare them as competent professionals employable in the extension and RAS.

Theory

Block 1: Educational Technology

Unit 1: The Landscape of Educational Technology and Instructional Design

Understanding various terms - educational technology, instructional design, instructional systems design, curriculum design, pedagogy, andragogy; Brief overview of the origin and evolution of ET and ID as theory and practice; what is the relevance of ET and ID relevant in extension and rural advisory services? Extensional professionals as instructional designers and architects of the learning experience

Unit 2: Theories of Learning

What is learning? Critical overview of Behaviorism, Cognitivism, Constructivism and Complex learning theories; instructional designers and learning theories; Types of learning or learning domains- Bloom's taxonomy of the cognitive domain, Krathwohl and Bloom's affective domain and Simpson's psychomotor domain

Unit 3: Technology Enabled Learning

What is the role of technology in education? Digital media, new tools and technology; Open and distance Learning (ODL); Online Education - Synchronous and Asynchronous learning models; eLearning, Massive Open Online Courses -SWAYAM, Open Education Resources (OERs), Course CERA, EduEx, CoL, RLOs; digital education and its applications in higher agricultural education; Smart classrooms and Campuses, Web-based remote laboratory (WBRL); Integrating media and digital tools into ID; types and implications of disruptive technologies for higher education and extension; Augmented learning; Adaptive learning; meaning, features and good practices in using open source Learning Management Systems (Moodle); Quality assurance and certification in e-learning.

Block 2: Instructional Design

Unit 1: Theories and Models of Instruction

Howard Gardner's Theory of Multiple Intelligences, David Kolb's Experiential Learning Cycle, Albert Bandura's Social Learning Theory, Rand Spiro's Cognitive Flexibility Theory and Its Application In eLearning, Wlodkowski's Motivational Framework for Culturally Responsive Adult Learning; ADDIE Model, Dick and Carey Model, SAM Model, Bloom's Taxonomy; integrating the theories of instruction into the practice of ID in extension and RAS ecosystem.

Unit 2: Creating Instruction

Overview of planning, designing, **Lesson Plan, Development of curricula** and implementing the curricula and learning experiences; Needs Analysis - meaning, approaches and steps; Task and content analysis - meaning, approaches, steps and techniques (topic analysis, procedural analysis, and the critical incident method); Learner analysis – meaning, importance and approaches, relevance of Maslow's Hierarchy of Needs and learning styles, Captive Audience vs. Willing Volunteers, universal vs. user-centered design, Learner Analysis procedures; Writing learning objectives: Meaning of Learning Goal and Learning Objectives; ABCDs of well-stated objectives; Setting goals, translating goals into objectives; Contextualising ADDIE process within the Extension learning environment

Unit 3: Instructional Strategies

Organizing content and learning activities - scope and sequence of instruction; Posner's levels of organizing (Macro, Micro, Vertical, and Horizontal) and structures of organizing (content vs. media) instruction, Gagne's events of instruction, Edgar Dale's Cone of Experience; Methods of Delivery- classroom teaching, programmed instruction, synchronous and asynchronous modes of distance education; Changing role of a teacher in classroom and teaching competencies

Unit 4: Evaluating Instruction

Meaning of Assessment, Measurement and Evaluation; Developing learner evaluations and their reliability & validity; assessment techniques for measuring change in knowledge, skill and attitude of learners -

Objective Test Items, Constructed-Response Tests, Direct Testing, Performance Ratings, Observations and Anecdotal Records, Rubrics, Portfolios, Surveys and Questionnaires, Self-Reporting Inventories, Interviews; Conducting learner evaluation pre-, during and post-instruction; Formative and Summative Evaluation- meaning, approaches and steps; Evaluating Learner Achievement and the Instructional Design Process; Evaluating the success of instruction; Performance appraisal of teachers

Unit 5: Trends in Instructional Design

Alternatives to ADDIE model - Rapid prototyping and constructivist ID, reflections on instructional design as science and as an art; Relating ID models and process in extension learning environment; political economy of higher education in developed and developing countries; University assessment and rating methods, returns from agricultural higher education; research in education and instructional design.

Practicals

- Exercises on preparation of the Analysis Report that includes the task/content analysis and learner analysis and the Design Plan includes learning objectives and corresponding instructional strategies and assessment items
- Prepare course outline and lesson plan with an appreciation for diverse learning styles based on temperament, gender, and cultural/ethnic differences and deliver a lecture for UG/PG students
- Assessing learning styles through Barsch and Kolb inventories
- Development and testing of survey instruments for evaluating learning outcomes/ competencies of students
- Development and testing of survey instruments for performance appraisal / competency assessment of teachers.
- Design an online e-learning module on a topic of interest as a capstone project - integrate and apply the knowledge and skills gained from the course for creating an effective learning experience for a target audience
- Designing and developing a theme based knowledge portals

- Exercises on designing an online course using open source LMS like moodle or EdX
- Select and evaluate or design for social al media
- Prepare a short research paper on recent theories and models of instructional design
- Interview an instructional designer of your choice and prepare a synthesis report about what job roles he/she perform, What ID processes does he or she use, challenges faced
- Develop a prototype for one of the lessons in your design plan using PowerPoint or a website builder such as Weebly to create the screens integrating multimedia content and various functionalities
- Field visit to a virtual learning / augmented learning labs, e-learning labs, distance learning centres, etc.
- Hands-on practice with video-editing software, web conferencing and video conferencing solutions

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AEE 605 RISK MANAGEMENT AND CLIMATE CHANGE ADAPTATION (2+1)

Objective

To provide both basic and applied knowledge on risks management and climate change adaptation with reference to Indian agriculture through multidisciplinary perspective and equipping them to identify, evaluate and evolve ways to address risks and climate change.

Theory

Block 1: Risk Management in Agriculture

Unit 1: Understanding Risk and Distress

Introduction to risk, risk management, uncertainty, sensitivity and distress, General risk theory, Risk analysis methods, Risk perception and decision making, Indicators of risk and distress in agriculture – identification, selection and assessment, Understanding the agrarian distress in Indian agriculture, Sources of distress in Indian farming - changing farm size, land use, cropping patterns, pricing policy, markets and terms of trade, Typology of crisis in agriculture; Droughts, floods and Indian agriculture, Distress and farmer suicides - causes and socio-economic consequences

Unit 2: Managing Risk and Distress

Ways to reducing/managing risk and distress in Indian agriculture; crop and life insurance; Developing support systems; Planning, implementation and evaluation of risk/distress management programs; Institutional frameworks for risk and disaster management - NDMA & SDMAs; Developing District Agriculture Contingency Plans; Risk management by diversification; Good practices and lessons from other countries;

Responses of government, non-government and extension system to agrarian crisis; National Farmers Policy.

Unit 3: Extension Professionals and Risk management

Understanding social-psychological and behavioural dimensions of farmers under risk/distress; Risk perception and communication; Helping farmers manage farm level risks - mobilising resources, linking with markets, strengthening capacities; Working with village level risk management committees; Operational skills for preparing contingency and disaster management plans; Institutional and extension innovations in managing risk and distress; Policy and technological preferences for dealing with drought and flood.

Block 2: Adapting to Climate Change

Unit 1: Introduction to Climate Change Science

Basic concepts of and terms in climate change science; impacts of climate change; anthropogenic drivers of climate change, Climate change and Indian agriculture; climate adaptation vs. disaster risk reduction; anticipated costs of adaptation;

climate change and poor; Overview of UNFCCC framework and institutions, Kyoto Protocol and beyond; India’s National Action Plan on Climate Change and National Mission on Strategic Knowledge on Climate Change; National Coastal Mission, Institutional arrangements for managing climate change agenda.

Unit 2: Introduction to Climate Change Adaptation and Mitigation

Introduction to Climate Change Adaptation, Conducting a vulnerability assessment (CVI and SEVI frameworks), Identifying and selecting adaptation options; Global, national and state level initiatives and plans to support climate change adaptation, private sector and civil society initiatives and activities; Mainstreaming climate change adaptation into development planning, Financing climate adaptation and budgetary allocations for programmes, Gender and climate change adaptation, Agricultural development programmes and strategies towards climate change adaptation and mitigation, Community based and Ecosystem based adaptation strategies, preparing evidence based intervention plans for vulnerability reduction at micro and macro-levels.

Unit 3: Climate Smart Agriculture (CSA) and Extension &Advisory Services

Climate smart agriculture; Developing climate smart and climate resilient villages; Stakeholders and determinants involved in climate smart agriculture; Climate smart agriculture and EAS; Innovative extension approaches used in CSA; Climate information services, Farmers perceptions about climate change; Farm and household level manifestations and adaptation strategies; Barriers and limits to adaptation; Farmers feedback on performance of extension methods; Skills, competencies and tools required for extension professionals at different levels and development departments in up scaling CSA.

Practicals

- Hands-on practice in using risk assessment/analysis tools
- Case studies on risk / distress assessment in agriculture -Indian and global
- Lessons / Experiences from NICRA Project in agriculture and allied sectors
- Developing criteria, indicators and indices for assessment of risk, vulnerability and resilience
- Hands on practice on use of vulnerability and risk assessment tools and techniques
- Case studies on success stories of climate change adaptation and community based initiatives

- Developing district and village level intervention plans for climate change adaptation
- Field Visits to State Disaster Management Authority
- Case studies on climate smart agriculture / villages from India and world
- Case studies on impact assessment of crop insurance programs, disaster management programs
- Capstone project on documenting ITKs and local practices related to reducing risk / climate resilience agriculture

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AEE 606 LIVELIHOOD DEVELOPMENT (1+1)

Objective

To orient the students on livelihood and its forms, alternative approaches to support livelihoods through multidisciplinary teams, familiarizing the methods, tools and techniques for designing livelihood interventions and expose them to the context, economic models and policy environments.

Theory

Block 1: Understanding of Livelihood

Unit 1: Concept of Livelihoods

Basic concepts of livelihood and Development, Types of development-Immanent/inherent and interventionist/ intentional; Why promote livelihood; Livelihood intervention: definition, types-Spatial, segmental, sector –sub-sector; Systemic viewof Livelihoods, Understanding Rural Livelihoods-Farm, Non-Farm, and off farm; Linkages with Farm and Off-farm Livelihoods; Economic Models

Unit 2: Livelihood Challenges

Livelihood Challenge- Political economy of Livelihoods, Issues of access to farm and non-farm livelihoods; Livelihoods from a Gender Perspective-Feminization of agriculture/ poverty, women in the unorganized sector, the issue of unpaid and informal work; Livelihood Coping Mechanism- Climate Change and Livelihoods; Livelihoods and Disasters

Block 2: Livelihood Analysis

Unit 1: Livelihood Frameworks

Sustainable Livelihoods Approaches (SLAs)-Definition and origins of SLA; Assets or capitals and capabilities in SLA and its linkage to the other capitals: Physical, Social, Economic, Human, Natural; Vulnerability Assessment- Shocks, trends, seasonality; Policies, institutional context and processes; Conceptual Frameworks-DFID, CARE, UNDP, OXFAM, BASIX livelihood triad, Nine square Mandala or Rural Livelihood System's Framework, *etc.*; Past, Present and possibilities for the future of the SLA, critiques of the approach.

Unit 2: Designing Livelihood Intervention and Promotion

Designing a suitable livelihood intervention-Observing and Understanding the Local Economy; Selecting livelihood activities suitable for the poor in the area; Deciding on the interventions. Livelihood promotion approaches-Poverty and livelihood:Approaches and programs in India; Livelihood and a Rights Based Approach-MGNREGA and its critique; Livelihood and a Social Capital based approach: NRLM.

Block 3: Livelihood Augmentation (LA)

Unit 1: Pathways for LA

Basic concepts; Pathways: a) Entrepreneurial strategies for LA; b) NRM based intervention; c) Market based interventions including Value-chain analysis; d) ICT based interventions; e) Livelihood and allied agriculture (dairy, poultry, Goatery, etc.) based livelihood; f) Forest based Livelihoods vis a vis Livelihood Protection and Promotion: Contribution of NTFP in supporting rural livelihoods Note: Block 'A' and 'B' is theoretical; Block 'C' should be covered in the form practical's supported by few classroom discussion through cases.

Practicals

- Village stays to understand the livelihood pattern of villagers and how the other socio-economic factors affect the livelihood of people
- Visit to institutes/ universities adopted and/or nearby villages to experience the life and natural resources in rural communities-understanding of village culture,evolution, social structure,

livelihood pattern, trends, governance arrangements, and the natural context (landscape layout, land use, vegetation types etc)

- Application of participatory rural appraisal skills for understanding village context; Engagement of working with rural communities and their grass-root institutions, understanding dynamics of working in a group
- Visit to different agri-business models as mentioned in the Block 'C'. Group assignments may be given to document the field experience in the form of case study of an enterprise/ entrepreneur/ members and other related stakeholders

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AEE 607 FACILITATION FOR PEOPLE CENTRIC DEVELOPMENT (2+1)

Objective

To orient students on the importance facilitation, facilitation tools to influence change at the individual, group and organizational levels and developing capacities in multi-stakeholder engagement, facilitation and networking.

Theory

Block 1: Introduction to Facilitation for Development

Unit 1: Facilitation for development in the AIS

Facilitation for development in the AIS; Understanding facilitation for development; Importance of facilitation as a core function of extension within the Agricultural Innovation Systems (AIS), Agricultural Knowledge Information System (AKIS).

Unit 2: Principles, Attributes and Skills for Facilitation for Development

Basic principles of facilitation for development; Desired attributes of facilitator for development- Cognitive attributes, Emotional attributes (Emotional intelligence), Social, behavioural and attitudinal attributes; Technical skills of a facilitator for development- Design processes, Facilitation techniques and tools, the art of questioning and probing, Process observation and documentation, Visualisation, **PRA Techniques.**

Block 2: Facilitating Change in Individuals, Groups and Organisations

Unit 1: Realise Potential- Self-Discovery

Self-discovery to realise our potentials, Tools for self-discovery, formulating a personal vision, Taking responsibility for your own development

Unit 2: Group Dynamics and Working Together

Understanding the dynamics of human interaction, Group dynamics and power relations, Managing relationships, Shared vision and collective action, Tools for team building.

Unit 3: Organizational Change Process

Organizational change process, Organizational learning to adapt to changing environments, Enhancing performance of organizations, Leadership development, Tools for organizational change.

Block 3: Facilitating Operational Level Multi-stakeholder Engagements

Unit 1: Multi-Stakeholder Interactions

Defining stakeholders, Development of collective and shared goals, Building trustand accountability, Tools for stakeholder identification and visioning

Unit 2: Innovation and Policy engagement Platforms

Visualising innovation platforms (IPs), Why are IPs important?, Different models of IPs for multi-stakeholder engagement, policy engagement platforms, Generating issues and evidence for policy action, Advocacy for responsive policy processes.

Block 4: Brokering Strategic Partnerships, Networking and Facilitation

Unit 1: Linkages, Partnerships, Alliances and Networking

Brokering linkages and strategic partnerships, Identification of critical links, Knowledge brokering, Creating linkages with markets, Learning alliances and networking, Coordination of pluralistic service provision within the AIS, The concept of action learning and reflective practitioners, Networking.

Unit 2: Facilitating Capacity Development

Facilitating Capacity Development-Facilitate participation and learning in development programs and projects. Virtual platforms- skills for strengthening dialogue, collaboration, shared commitment amongst diverse actors and stakeholders.

Practicals

- Practicing facilitation techniques,
- Self-discovery exercises,
- Working together and interaction (task based),
- Arrangement for multi-stakeholder interactions,
- Understanding organisational change process tools and techniques,
- Case analysis on organisational change process,
- Participating with innovation platforms,

- Policy engagement platforms,
- Stakeholder analysis mapping,
- Exercise on networking skills,
- Facilitating capacity building programmes
- Facilitating virtual platforms
- Filed visit to multi-stakeholder partnership projects

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Ph.D. in Agronomy

Course Code	Course Title	Credit Hours
AGR 601	Current Trends in Agronomy	3(3+0)
AGR 602	Recent Trends in Crop Growth and Productivity	3(2+1)
AGR 603	Irrigation Management	3(2+1)
AGR 604	Recent Trends in Weed Management	2(2+0)
AGR 605	Integrated Farming Systems and Sustainable Agriculture	2(2+0)
AGR 606	Soil Conservation and Watershed Management	3(2+1)
AGR 607	Stress Crop Production	3(2+1)
AGR 608	Research and Publication Ethics	2(2+0)
	Total	**21 (17+4)**
AGR 680	Qualifying Examination	3 (0+3)
AGR 681	Seminar -I	1 (0+1)
AGR 682	Seminar - II	1 (0+1)
AGR 683	Teaching Assistantship -I	1 (0+1)
AGR 684	Teaching Assistantship - II	1 (0+1)
AGR 691	Research -I	18 (0+18)
AGR 692	Research -II	18 (0+18)
AGR 693	Research -III	18 (0+18)
AGR 694	Research -IV	18 (0+18)

AGR 601 CURRENT TRENDS IN AGRONOMY (3+0)

Objective

To acquaint the students about recent advances in agricultural production

Theory

Block I: Agro-physiological basis for crop production

Unit1: Agro-physiological basis of variation in yield, recent advances in soil plant-water relationship.

Unit 2: Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming.

Unit 3: Crop residue management in multiple cropping systems; latest developments in plant management, Mechanization in crop production: modern agricultural precision tools and technologies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

Block II: Recent trends in crop production

Unit 1: GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

Unit 2: Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues.

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AGR 602 RECENT TRENDS IN CROP GROWTH AND PRODUCTIVITY (2+1)

Objective

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

Theory

Block I: Crop growth and analysis

Unit 1: Plant density and crop productivity; effect of plant and environmental factors, yield, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield;

Unit 2: Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rain fed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

Block II: Crop growth and yield relationship

Unit 1: Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; concept of heat units.

Unit 2: Concept of plant ideo types: crop physiological and new ideo types; characteristics of ideo type for wheat, rice, maize, *etc.*; concept and types of growth hormones; their role in field crop production; efficient use of resources.

Practical

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI *etc.*, at different stages of crop growth
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, *viz.* LER, IER aggressivity competition index etc in intercropping
- Senescence and abscission indices
- Analysis of productivity trend in un-rainfed areas
- Analysis of productivity trend in irrigated areas

References

- CHOPRA, V. L. AND PARODA, R. S. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. Oxford & IBH.
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AGR 603 IRRIGATION MANAGEMENT (2+1)

Objectives: To teach students about optimization of irrigation in different crops / situation under variable agro climatic conditions.

Theory

Block I: Water resources and its utilization

Unit 1: Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit 2: Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil.

Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

Unit 3: Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

Unit 4: Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirents; fertilizer use in relation to irrigation.

Unit 5: Crop water stress – water deficits and crop growth, adoptability to the crops.Water availability with relation to nutrient availability.

Block II: Water resource management

Unit 1: Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

Unit 2: Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

Unit 3: Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Unit 4: Economic analysis of irrigation and cop planning for optimum use of irrigation water

Unit 5: Crop water production function

Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles.
- Determination moisture extraction pattern of crops

- Determination of water balance component of transplanted rice by drum culture technique
- Determination of consumptive use and water requirement of a given cropping pattern
- Determination of crop co-efficient of one important crop
- Planning, designing and installation of drip irrigation system
- Planning, designing and installation of sprinkler irrigation system
- Designing of drainage channel
- Measurement of irrigation efficiencies
- Determination of irrigation timing under different methods of irrigation
- Visit to irrigation command area

References

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AGR 604 RECENT TRENDS IN WEED MANAGEMENT (2+0)

Objective

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory

Block I: Biology and management of weeds

Unit 1: Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management.

Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion.

Unit 2: Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; Principles of selectivity of herbicides and factors affecting them.

Unit 3: Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Block II: Recent trends in herbicide technology

Unit 1: Advances in herbicide products and application techniques and methods; herbicide resistance in weeds; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit 2: Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

Unit 3: Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelo chemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

References

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- ZIMDAHL, R. L. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub*

AGR 605 INTEGRATED FARMING SYSTEM AND SUSTAINABLE AGRICULTURE (2+0)

Objective

To apprise about different enterprises suitable for different agroclimatic conditions for sustainable agriculture.

Block I: Integrated farming system and concepts of sustainability

Unit 1: Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/ irrigated condition in different land situation. farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

Unit 2: Concept of sustainability in Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources – identification and management.

Unit 3: Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information in different systems through research; eco-physiological approaches to intercropping. Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; evaluation of IFS.

Block II: Farming system models and evaluation

Unit 1: Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. Formation of different Integrated Farming system Models; evaluation of different Integrated Farming system models. Recycling of organic waste in farming system, in IFS.

Unit 2: New concepts and approaches of farming system and organic farming; value addition, waste recycling, quantification and mitigation of Green House gases; case studies/ success stories of different Integrated Farming systems. Cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in Integrated farming system.

References

- ANANTHA KRISHNAN, T. N. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.
- BAISHYA, A, BORAH, M, DAS, A. K., HAZARIKA, J., GOGOI, B. AND BORAH, A. S. 2017. *Waste Recycling Through Integrated Farming systems. An Assam Agriculture Experience.* Omni Scriptum Gmbh & Co. KG, Germany.

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AGR 606 SOIL CONSERVATION AND WATERSHED MANAGEMENT (2+1)

Objective: To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

Theory

Block I: Soil conservation

Unit 1: Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

Unit 2: Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

Block II: Watershed management

Unit 1: Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

Unit 2: Land use capability classification, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout.

Unit 3: Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

Practical

- Study of different types of erosion
- Determination of dispersion ratio
- Estimation of soil loss by Universal Soil Loss Equation
- Estimation of soil loss by wind erosion
- Measurement of runoff and soil loss
- Field studies of different soil conservation measures
- Laying of run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to watershed areas
- Visit to a soil conservation research centre, demonstration and training centre

References

- ARAKERI, H. R AND ROY, D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.
- DHRUVA NARAYANA, V. V., 1993. *Soil and Water Conservation Research in India*. ICAR.

- FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas*. *Soils Bull.,* Paper 57.
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AGR 607 STRESS CROP PRODUCTION (2+1)

Objective

To study various types of stresses in crop production and strategies to overcome them.

Theory

Block I: Moisture and temperature stress

Unit 1: Stress and strain terminology; nature and stress injury and resistance; causes of stress.

Unit 2: Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature tress through, soil and crop manipulations.

Unit 3: High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

Unit 4: Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

Unit 5: Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

Block II: Salt stress and mechanical impedance

Unit 1: Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

Unit 2: Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

Unit 3: Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Measurement of Relative Water Content of leaf
- Measurement of electrolytic leakage
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions
- Studies on plant responses to excess water.

References

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- GUPTA, U. S., (Ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.

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- MAVI, H. S., 1978. *Introduction to Agro-meteorology*. Oxford & IBH.
- MICHAEL, A. M. AND OJHA, T. P., 1981. *Principles of Agricultural Engineering*. Vol II. Jain Bros.
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AGR 608 RESEARCH AND PUBLICATION ETHICS (2+0)

Objective

To teach about the Research and Publication Ethics

Theory

Block I: Philosophy of research

Unit 1: Introduction to philosophy: definition, nature and scope, concept, branches

Unit 2: Ethics: definition, moral philosophy, nature of moral judgements and reactions.

Unit 3: Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP):

Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data.

Block II: Publication ethics

Unit 1: Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit 2: Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools *viz.,* JANE, Elsevier Journal Finder, Springer Journal Suggester *etc.*

Unit 3: Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit 4: Database and Research metrics: Indexing data base, citation database, web of science, scopus, *etc.* Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics.

References

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Ph.D. in Biochemistry

Course Code	Course Title	Credit Hours
BCM 601	Advanced Enzymology	3 (2+1)
BCM 602	Advanced Molecular Biology	3 (3+0)
BCM 603	Biochemistry of Biotic and Abiotic Stress	3 (3+0)
BCM 604	Frontier Topics in Biochemistry	2 (2+0)
BCM 605	Concepts and Application of Omics in Biological Science	3 (3+0)
BCM 606	Bio-membranes	2 (2+0)
BCM 607	Application of Techniques in Biochemistry	3 (1+2)
BCM 608	Nutritional Biochemistry of Nutri-Cereals	2 (2+0)
	Total	**21 (18+3)**
BCM 680	Qualifying Examination	3 (0+3)
BCM 681	Seminar - I	1 (0+1)
BCM 682	Seminar - II	1 (0+1)
BCM 683	Teaching Assistantship - I	1 (0+1)
BCM 684	Teaching Assistantship - II	1 (0+1)
BCM 691	Research - I	18 (0+18)
BCM 692	Research - II	18 (0+18)
BCM 693	Research - III	18 (0+18)
BCM 694	Research - IV	18 (0+18)

BCM 601 ADVANCED ENZYMOLOGY (2+1)

Objective

The course will make the students able to have understanding on conceptual analysis of the enzymatic reaction mechanism and know the principles of the application of enzymes in analytical biochemistry and industrial systems.

To provide advanced knowledge about the structure of enzymes, mechanism, kinetics and regulation of enzymatic reactions and use of enzymes as biosensors.

Theory

Block 1: ENZYMOLOGY AND ENZYME ENGINEERING

Unit 1: Enzyme catalysis and specificity (Seven lectures)

Theory of enzymatic catalysis, Specificity and editing mechanisms, concept of active site and enzyme substrate complex, active site mapping, factors associated with catalytic efficiency, mechanism of enzyme reactions, detection of intermediates in enzymatic reactions.

Unit 2: Enzyme kinetics (Seven lectures)

Transition state theory, Arrhenius equation, Determination of energy of activation, effect of pH and temperature on enzyme kinetics, pre-steady state and steady state kinetics, single substrate kinetics, allosteric enzymes and mixed inhibition, substrate and product inhibition, numerical exercises.

Unit 3: Enzyme mechanism and regulation (Seven lectures)

Mechanism determination by radioisotope exchange, role of enzymes in regulation of metabolism, bifunctional enzymes, pseudo enzyme and enzyme promiscuity, extremozymes, catalytic nucleic acids (ribozymes, catalytic DNA).

Block 2: INDUSTRIAL ENZYMOLOGY

Unit 1: Industrial enzymology (Seven lectures)

Advantages and disadvantages of biocatalysts in technology driven processes, stabilization and regeneration of enzyme systems used in biotechnology, protein engineering of enzymes, creation of chimeric, bifunctional, immobilization of enzymes, semisynthetic enzymes and their use as industrial biocatalysts, and their practical significance, modern information technologies in enzyme engineering.

Practical

1. Purification and characterization of some model enzymes (peroxidise, á-amylase, lipase).
2. Study kinetics of inhibited and un inhibited enzyme catalysed reactions.

3. Determination of Km values of single substrate reactions.
4. Determination of enzyme activity by coupled assay.
5. Electrophoretic separation of isozymes.
6. Enzyme immobilization.

References

- AEHLE, W., 2007, Enzymes in Industry.Production and Application. (Third, Completely Revised Edition). WILEY-VCH Verlag GmbH & Co. KGaA Buchholz, K., Bornscheuer, U., Kasche, V. 2012. Biocatalysts and Enzyme Technology. UK: Wiley-VCH Verlag GmbH
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- YOUNG JE YOO, YAN FENG, YONG-HWAN KIM, CAMILA FLOR J. YAGONIA., 2017. Fundamentals of Enzyme Engineering. Springer.

BCM 602 ADVANCED MOLECULAR BIOLOGY (3+0)

Objective

To impart knowledge on genome organization and analysis, gene expression and its regulation and modern techniques for genome

To provide latest information on structure and organisation of genetic materials; genes, their expression in plants and biochemical approaches employed in genetic engineering.

Theory

Block 1: GENOME ORGANISATION AND MANIPULATION

Unit 1: Concepts of gene and genome (Five lectures)

Genes, their relationship with chromosomes, gene number hypothesis; Genome – definition, variation and organisation in plants and animals, structure of organelle genomes; concept of epigenome, genome size and genome evolution.

Unit 2: Regulation of gene expression (Six lectures)

Prokaryotic and eukaryotic gene regulation, transcriptional and posttranscriptional regulation; regulation at genome level, role of histones, riboswitches.

Unit 3: Techniques in genome analysis (Six lectures)

Genome sequencing technologies, Sanger sequencing, next generation sequencing, nanopore sequencing; genome mapping – genetic map construction, physical mapping.

Unit 4: Techniques for gene transfer and genome manipulation (Six lectures) Methods of gene isolation and transfer in plants and animals, agrobacterium mediated and direct transfer of genes in plants; gene silencing technologies: virus induced gene silencing, RNA silencing; genome editing-TALENs, CRISPR/Cas, ZNF and their application, site directed mutagenesis, Application of genetic engineering in different fields, gene therapy.

Block 2: MOLECULAR BREEDING

Unit 1: Aspects of molecular breeding (Five lectures)

Genome browsing, primer design, marker application for breeding, application of MAS in case studies.Bioethics and biosafety guidelines, IPR in recombinant DNA research.

Resources

- BROWN, T. A., 2018, Genomes 4. Garland Science.
- RIPPE, K., 2011, Genome Organization and Function in the Cell Nucleus. Wiley-VCH Verlag.
- PRIMROSE, S. B. AND TWYMAN, R., 2006, Principle of Gene Manipulation and Genomics 7th edition. Blackwell Publishing
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- S. MOHAN JAIN, D. S. BRAR., (eds.), 2009, Molecular Techniques in Crop Improvement. 2nd edition. Springer.
- BOOPATHI, N. M., 2013, Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits. Springer.
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- SINGH, K. K., 2015, Biotechnology and Intellectual Property Rights. Legal and Social Implications.Springer.

BCM 603 BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESS (3+0)

Objective

Plants are constantly confronted to both abiotic and biotic stresses that seriously reduce their productivity. Plant responses to these stresses involve numerous physiological, biochemical, molecular, and cellular adaptations. This course will help to have an insight into the mechanism underlying the stress tolerance and to elucidate the molecular basis of stress adaptation.

To impart knowledge on biochemistry of biotic and abiotic stresses in plants.

Theory

BLOCK 1: BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES

Unit 1: Plant-pathogen interaction and disease development(Four lectures)

Molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

Unit 2: Biochemistry of plant defence mechanisms (Seven lectures)

Role of secondary metabolites, Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, pathogen derived resistance

Unit 3: Plant host-virus interaction (Four lectures)

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids.

Unit 4: Biochemical basis of abiotic stresses(Seven lectures)

Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

BLOCK 2: BIOTIC AND ABIOTIC STRESS TOLERANCE

Unit 1: Tolerance against stress (Six lectures)

Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes of defense system.Role of calcium, nitric oxide and salicylic acid in plant development.Molecular strategies for imparting tolerance against biotic and abiotic stress.

References

- BUCHANAN, BOB B., GRUISEM, W. AND JONES, R., 2015, Biochemistry and molecular biology of plants, 2nd edition, Wiley Blackwell
- DRESSELHAUS, T. AND HÜCKELHOVEN, R., (Eds.), 2019, Biotic and Abiotic Stress Responses in Crop Plants. MDPI. https://doi.org/10.3390/agronomy8110267
- ROUT, G. R. AND DAS, A. B., 2013, Molecular Stress Physiology of Plants. Springer. DOI 10.1007/978-81-322-0807-5
- SHANKER, A. K. AND SHANKER, C., (Eds.), 2016, Abiotic and Biotic Stress in Plants - Recent Advances and Future Perspectives.InTech. http://dx.doi.org/10.5772/60477

- RAMAKRISHNA, A. AND GILL, S. S., 2018, Metabolic Adaptations in Plants During Abiotic Stress. CRC Press
- KHAN, M. I. R. AND KHAN, N. A., (Eds.), 2017, Reactive Oxygen Species and Antioxidant Systems in Plants: Role and Regulation under Abiotic Stress. Springer
- SMIRNOFF, N., (ed.), 2005, Antioxidants and reactive oxygen species in plants, Blackwell.

BCM 604 FRONTIER TOPICS IN BIOCHEMISTRY (2+0)

Objective

To update the students to the recent developments in various fields of biochemistry. To acquaint the students with the advanced developments in the field of biochemistry and to inculcate the habit of searching and reading the topics of current importance

Theory

Block 1: FRONTIER TOPICS IN BIOCHEMISTRY

Unit 1: Latest development in metabolic nutrition.

Unit 2: Latest development in environmental and industrial biochemistry

Unit 3: Latest development in metabolic engineering

Unit 4: Latest development in regulation of gene expression

Unit 5: Latest development in biotic and abiotic stress response in plants

Unit 6: Latest development in protein chemistry

Block 2: FRONTIER TOPICS IN BIOCHEMICAL TECHNIQUES

Unit 1: Latest development in application of biochemical tools and techniques

Unit 2: Latest development in molecular biology techniques.

Unit 3: Latest development in Phytochemistry related techniques

References

- Selected articles from recent issues of Thomson Reuters and NAAS rated journals

BCM 605 CONCEPTS AND APLICATION OF OMICS IN BIOLOGICAL SCIENCE (3+0)

Objective

Omics is a rapidly evolving, multi-disciplinary, and emerging field that encompasses genomics, epigenomics, transcriptomics, proteomics, and metabolomics. This course will be helpful for the students to understand the scope of omics research and methods therein

To impart knowledge in the upcoming areas of biochemistry and to understand the recent developments in omic technologies.

Theory

Block 1: CONCEPTS AND APLICATION OF OMICS IN BIOLOGICAL SCIENCE

Unit 1: Protein and nucleic acid sequencing (Seven lectures)

Various methods of sequencing including automated sequencing and microarrays, whole genome sequence analysis.

Unit 2 : Genomics – methods of analysis and application(Seven lectures)

Comparative genomics, functional genomics, nutrigenomics, transcriptomics, gene identification, gene annotation, pairwise and multiple alignments, application of genomics, quantitative PCR, SAGE, MPSS, microarray, RNA sequence Analysis, NGS analysis, NGT, de-novo assembly, role of bioinformatics in functional genomics

Block 2: TECHNIQUES IN PROTEOME AND METABOLOME ANALYSIS

Unit 1: Proteome technology(Seven lectures)

2D-PAGE, MSMS, MALDI-TOF, comparative proteomics and structural proteomics.

Unit 2: Metabolomics and ionomics (Seven lectures)

Elucidation of metabolic pathways, Sample preparation for metabolomics. Techniques involved in metabolite identification- LCMS, NMR, FTIR, MS. Metabolomics in biotic and abiotic stress in crop plants, SPE, SPME, metabolic pathway engineering and its application, Concept and application of ionome and ionomics.

References

- LIEBER, D. C., 2002, Introduction to Proteomics - Tools for the New Biology. Humana Press.
- LEUNG, H. E., 2012, Integrative Proteomics. InTech
- LESK, A. M., 2012, Introduction to Genomics, 2nd Edition. Oxford University Press
- AIZAT, W. M., GOH, H-H. AND BAHARUM, S. N., (Eds.), 2018, Omics Applications for Systems Biology. Springer International Publishing
- ARIVARADARAJAN, P., MISRA, G., (Eds.), 2018, Omics Approaches, Technologies and Applications. Springer Singapore
- TERESA WHEI-MEI FAN, ANDREW N. LANE. AND RICHARD, M. HIGASHI., (Eds.), 2012, The Handbook of Metabolomics.Humana Press, Totowa, NJ.

BCM 606 BIO-MEMBRANES (2+0)

Objective

Biomembranes define the boundaries of cells and their internal organelles and, consequently, are fundamental to the compartmentalisation of vital enzymatic reactions. This course will help the students to acquire an integrated overview of the structure, function and biogenesis of biological membranes and their components and their impacts on different cell activities

To impart knowledge on the molecular basis of the structure, function and biogenesis of eukaryotic cell membranes

Theory

BLOCK 1: BIO-MEMBRANES

Unit 1: Bio-membranes

Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, cell surface receptors and antigen

Unit 2: Membrane biogenesis and organization

Membrane biogenesis and differentiation; membrane components-lipids, their distribution and organization; proteins, intrinsic and extrinsic, their arrangement; carbohydrates in membranes and their function.

Unit 3: Membrane Movement and Membrane transport systems

Various membrane movements; Membrane transport: Organization of transport at plant membranes, pumps, carriers, ion channels, water transport through aquaporins, transport of macro molecules: exocytosis and endocytosis, energy transduction

Unit 4: Membranes and cellular function

Role of membrane in cellular metabolism, cell recognition and cell –to –cell interaction. Recent trends and tools in membrane research

Unit 5 General principles of Signal Transduction and Plant Communication (3 lectures): Membrane receptors, second messengers, sensor proteins signal integrators. Mitogen-Activated Protein Kinase (MAPK) Pathway, Calcium dependent signaling pathway, NO signaling pathway, ROS mediated signaling.Cross talk between signaling pathways. Plant- communication via chemical signals, the potential applications of chemical ecology in Agriculture. Plant communication via audio signals, mycorrhizal networks, and electrical signals.

References

- WATSON, H., 2015, Biological membranes. Essays Biochem. 59, 43-70: doi: 10.1042/BSE0590043
- SHINITZKY, M., 2008, Biomembranes: Structural and Functional Aspects. VCH. DOI:10.1002/9783527616114
- BERK, A., KAISER, C. A., LODISH, H., AMON, A., PLOEGH, H., BRETSCHER, A., KRIEGER, M. AND MARTIN, K. C., 2016, Molecular Cell Biology. Macmillan Learning
- STILLWELL, W., 2013, An Introduction to Biological Membrane: From Bilayers to Rafts Elsevier
- YEAGLE, P., 2016, The Membranes of Cell. 3rd edition. Academic Press.

BCM 607 APPLICATION OF TECHNIQUES IN BIOCHEMISTRY (1+2)

Objective

This course will provide the students the theoretical basis of various separation techniques and their application with practical experience in the use of different biochemical and molecular biology techniques.

To train students the application of cutting edge laboratory techniques in research in biochemistry and molecular biology.

Theory

BLOCK 1: APPLICATION OF TECHNIQUES IN BIO-CHEMISTRY

Unit 1: Isolation, purification and analysis of metabolites

Isolation and purification of important metabolites from microbial/ plant/animal source, Applications of paper, thin layer and gas liquid chromatography, PAGE, FPLC and HPLC in the separation of biomolecules/proteins. Determination of molecular weight of protein using PAGE/ gel filtration method.

Unit 2: Electrophoretic separation

Electrophoretic separation of protein, Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA. Techniques in DNA-protein and protein-protein interaction.

Unit 3: Application of centrifugation

Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation.

Unit 4: Enzyme techniques

Isolation, purification and characterization of enzymes, isozyme analysis and enzyme immobilization

Unit 5: Molecular biology and immunochemical techniques

Application of PCR, yeast 2 hybrid system, Antigen-Antibody interaction, ELISA, Chromatin immunoprecipitation, gel based and gel free proteasome tools.

Block 2: METABOLITE ANALYSIS

Unit 1: Recent advances in secondary metabolite extractions methodologies :

Phytochemical Finger Printing, HPTLC and LCMS/GCMS applications in the characterization of herbal extract. Separation of phytoconstituents by CCCET, SCFE techniques including preparative HPLC and Flash column chromatography.

Practical

1. Preparation of buffers
2. Estimation of soluble protein by Lowry's method.
3. Fatty acid analysis by Gas liquid chromatography.
4. Separation/estimation of bio-molecules by HPLC/ FPLC
5. Purification of proteins using ion exchange, gel filtration and affinity chromatography

6. Determination of molecular weight of proteins using PAGE/ gel filtration method

7. Isolation, purification and characterization of a model enzyme

8. Electrophoretic separation of isozymes

9. Fractionation of plant cell organelles (chloroplast, mitochondria, nucleus) by differential centrifugation, and their purification by density gradient centrifugation.

10. Isolation of DNA and RNA, and separation/purification by agarose gel electrophoresis

11. PCR and RT-PCR

12. ELISA

References

- KATOCH, R., 2011, Analytical Techniques in Biochemistry and Molecular Biology. Springer
- WILSON, K. AND WALKER, J., 2010, Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press
- HEGYI, G., KARDOS, J., KOVÁCS, M., MÁLNÁSI-CSIZMADIA, A., NYITRAY, L. PÁL, G., RADNAI, L., REMÉNYI, A. AND VENEKEI, I., 2013, Introduction to Practical Biochemistry. EötvösLoránd University.

BCM 608 NUTRITIONAL BIOCHEMISTRY OF NUTRI-CEREALS (2+0)

Objective

This course will provide the students the theoretical basis of nutrition and its health benefit with respect to different cereals, nutraceutical aspects and bioprocessing.

Theory

Unit 1 : Introduction to millets

Types of millets - Pearl millet, Sorghum, Finger millet, Minor millets (Fox tail millet, Barn yard millet, Proso millet, Kodo millet, Little millet) and pseudo- cereals (Grain amaranth, Buckwheat, Quinoa). Role of millets in contributing to food and nutritional security; genesis of their declaration as Nutri-cereals.

Unit 2: Nutrient composition of millets

Carbohydrates, protein, fat, dietary fibre (total, soluble, insoluble), vitamins, minerals, energy value.Nutritional characteristics of carbohydrates, protein (essential amino acids), fat (essential fatty acids), fibre.True Digestibility (TD) and Biological Value (BV) of proteins. Low glycemic index (GI) of millets.

Unit 3: Nutraceauticals

Millets as a rich source of phenolic acids, flavonoids, condensed tannins, anthocyanins, pinacosanols, tocopherols, phytosterols and arabinoxylan, Anti-oxidant activity of these phytochemicals. Potential health benefits of nutri-cereals. Finger millet as a baby food.

Unit 4: Millets as a source of micro nutrients

Bio-fortification of millets for further enrichment with Fe and Zn, and their levels in released bio-fortified and normal varieties.

Unit 5: Anti-nutritional factors present in millets

Polyphenols, goitrogen, phytates, trypsin inhibitors. Factors affecting the bioavailability of mineral elements and digestibility of proteins.Rancidity, and off flavor development and low shelf-life of flour and products of millets rich in fat.

Block 2: BIOPROCESSING TECHNOLOGIES

Unit 1: Bioprocessing technology for reducing the levels of phytic acid, and enhancing the bioavailability of nutrients and improving shelf-life. Potential use of crop breeding/genetic engineering in reducing the content of phytic acid, and in lowering synthesis of lipase and other enzymes for tackling rancidity problem.

Reference

- TOMAR, M., BHARDWAJ, R., KUMAR, M., SINGH, S. P., KRISHNAN, V., KANSAL, R., VERMA, R., YADAV, V. K., DAHUJA, A., AHLAWAT, S. P., RANA, J. C., KUMAR, R. R., GOSWAMI, S., VINUTHA T., SATYAVATHI, C. T., PRAVEEN, S. AND SACHDEV, A., 2021., Nutritional composition of pearl millet and application of mulvariate analysis to evaluate indigenous Pearl millet (*Pennisetumglaucum* (L.) germplasm, J. Food Compost Anal, 103: 104086.

- KATOCH, R., 2011, Analytical Techniques in Biochemistry and Molecular Biology. Springer.

- WILSON, K. AND WALKER, J., 2010, Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press.

- S. CHANGMEI AND JAGANATHAN, D., 2014, Millet- the Frugal Grain. *IJSRR 2014,* 3(4), 75 - 90.

Ph.D. in Entomology

Course Code	Course Title	Credit Hours
ENT 601	Insect Phylogeny and Systematics	3 (2+1)
ENT 602	Insect Physiology and Nutrition	3 (2+1)
ENT 603	Insect Ecology and Diversity	3 (2+1)
ENT 604	Insect Behaviour	2 (1+1)
ENT 605	Bio Inputs for Pest Management	3 (2+1)
ENT 606	Insect Toxicology and Residues	3 (2+1)
ENT 607	Plant Resistance to Insects	2 (1+1)
ENT 608	Acarology	2 (1+1)
ENT 609	Molecular Entomology	2 (1+1)
ENT 610	Integrated Pest management	2 (2+0)
	Total	**25(16+9)**
ENT 680	Qualifying Examination	3 (0+3)
ENT 681	Seminar -I	1 (0+1)
ENT 682	Seminar - II	1 (0+1)
ENT 683	Teaching Assistantship -I	1 (0+1)
ENT 684	Teaching Assistantship - II	1 (0+1)
ENT 691	Research -I	18 (0+18)
ENT 692	Research -II	18 (0+18)
ENT 693	Research -III	18 (0+18)
ENT 694	Research -IV	18 (0+18)

ENT 601 INSECT PHYLOGENY AND SYSTEMATICS (2+1)

Objective

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. Detailed study about the International Code of Zoological Nomenclature; ethics and procedure for taxonomic publications.

Theory

Block–1: Insect classification

Unit 1: Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.

Block–2: Evolutionary classification of insects

Unit 1: Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

Block–3: ICZN protocols and procedures

Unit 1: Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.

Block–4: Insect taxonomy and database

Unit 1: Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, *etc.* Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular systematics.

Practical

Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, and construction of taxonomic keys for the selected group. Development of descriptions, photographing, writing diagrams, and preparation of specimens for “type like” preservation. Submission of the collections made of the group. Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms.

References

- CSIRO, 1990, The Insects of Australia: A text book for students and researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
- DAKESHOTT, J. AND WHITTEN, M. A., 1994, Molecular Approaches to Fundamental and Applied Entomology. Springer-Verlag, Berlin.
- FREEMAN, S. AND HERRON, J. C. 1998, Evolutionary Analysis. Prentice Hall, New Delhi. Hennig W. 1960. Phylogenetic Systematics. Urbana Univ. Illinois Press, USA.
- HOY, M. A. 2003, Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
- MAYR, E. AND ASHLOCK, P. D. 1991, Principles of Systematic Zoology. 2nd Ed. McGraw HILL, New York.
- MAYR, E., 1969, Principles of Systematic Zoology. McGraw-Hill, New York.
- QUICKE, D. L. J., 1993, Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional, London.
- ROSS, H. H. 1974, BIOLogical Systematics. Addison Wesley Publ. Co., London.
- WILEY, E. O. 1981, Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists. Columbia Univ. Press, USA.

ENT 602 INSECT PHYSIOLOGY AND NUTRITION (2+1)

Objective

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones etc.

Theory

Block–1: Insect cuticle, chitin and digestion

Unit 1: Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticle.

Unit 2 : Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.

Block–2: Nervous and sensory system

Unit 1: Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semio-chemicals in insect life, toxins and defence mechanisms.

Block–3: Inset hormones and pest management

Unit 1: Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

Practical

Preparation of synthetic diets for different groups of insects; rearing of insects on synthetic, semi- synthetic and natural diets; determination of co-efficient of utilization; qualitative and quantitative profile of bio-molecules; determination of chitin in insect cuticle; examination and count of insect haemocytes.

References

- BLUM, M. S. 1985, Fundamentals of Insect Physiology, Wiley, New York.
- BURSELL, E., 1970, An Introduction to Insect Physiology. Academic press, New york.

- CHAPMAN, R. F., 1998, The Insects Structure and Function. Fourth Edition. Cambridge University Press, Cambridge, UK.
- KERUKUT, G. A. AND L. I. GILBERT, 1985, Advances in Insects Physiology. Comprehensive
- Insect Physiology, Biochemistry and Pharmacology. Vol I-XIII, Pergamon Press, Oxford.
- MILLER, T. A. 1985, Insect neurophysiological techniques. Springer Verlag, New York.
- MORDUE, W., G. J. GOLDS WORTHY, J. BRANDY AND W. M. BLANEY, 1980, Insect Physiology, New York.
- ROCKSTEIN, M., 1974, The Physiology of Insect (Vol I to V) Academic Press New York.
- WIGGLESWORTH, V. B., 1972, The Principles of Insect Physiology. Seventh Edition. Chapman and Hall. London.

ENT 603 INSECT ECOLOGY AND DIVERSITY (2+1)

Objective

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics. Study insect-plant interactions; get acquainted with biodiversity and conservation.

Theory

Block–1: Distribution and indices of dispersion of insects

Unit 1 : Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

Block–2: Inset plant interactions and evolution of herbivory

Unit 1: Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites. Meaning of stress-plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. Host seeking behavior of parasitoids.

Block–3: Biodiversity and conservation of insects, Foraging ecology and ecological indicators

Unit 1 : Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

Block–4: Reproductive ecology of insects

Unit 1 : Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

Practical

Methods of data collection under field conditions. Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc. Calculation of sample sizes by different methods. Fitting Poisson and Negative Binomial distributions and working out the data transformation methods. Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies – Calculation of changes under selection, Demonstration of genetic drift. Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/Goniozus/Female Bruchids etc.-

A test of reproductive effort and fitness. Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution. Exercises in development of Algorithms for crop modelling.

References

- BARBOSA, P. AND LETOURNEAU, D. K., (Eds.), 1988, Novel Aspects of Insect-Plant Interactions. Wiley, London.
- ELIZABETH, B. A. AND CHAPMAN, R. F., 1994, Host-Plant Selection by Phytophagous Insects. Chapman and Hall, New York.
- FREEMAN S AND HERRON J. C., 1998, Evolutionary Analysis. Prentice Hall, New Delhi.
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- MAGURRAN, A. E., 1988, Ecological Diversity and its Measurement. Princeton University Press, Princeton.
- REAL, L. A. AND BROWN, J. H. (Eds.), 1991, Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, USA.
- SOUTHWOOD, T. R. E. AND HENDERSON, P. A. 2000, Ecological Methods. 3rd Ed. Wiley Blackwell, London.
- STRONG, D. R., LAWTON, J. H. AND SOUTHWOOD, R. 1984, Insects on Plants: Community Patterns and Mechanism. Harward University Press, Harward.

- WRATTEN, S. D. AND FRY G.L.A. 1980, Field and Laboratory Exercises in Ecology. Arnold Publ., London.

ENT 604 INSECT BEHAVIOUR (1+1)

Objective

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics. Study insect-plant interactions; get acquainted with biodiversity and conservation.

Theory

Block 1: Concept, history and basis for evolutionary behaviour in insects

Unit 1: Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behavior, inducted behavior, learnt behavior and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behavior- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behavior and behavioural polymorphism.

Block–2: Role and types of orientation, communication and defence behaviour in insects

Unit 1: Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

Block 3: Reproductive and social behaviour in insects

Unit 1: Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour- kin selection, parental manipulation and mutualism; Self organization and insect behaviour.

Block 4: Foraging and insect behaviour in insects

Unit 1: Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behaviour, pollination behaviour, co-evolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio- chemicals, auditory stimuli and visual signals in pest management.

Practical

Quantitative methods in sampling behaviour; training bees to artificial feeders; sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees. Evaluation of different types of traps against fruit flies with respect to signals; Use of honey bees/ *Helicoverpaarmigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

References

- ANANTHKRISHNAN, T. N. (Ed.), 1994, Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.
- AWASTHI, V. B. 2001, Principles of Insect Behaviour. Scientific Publ., Jodhpur.
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- MATHEWS, R. W. AND MATHEWS, J. R., 1978, Insect Behaviour. A Wiley-Inter Science Publ. John Wiley and Sons, New York.

ENT 605 BIO-INPUTS FOR PEST MANAGEMENT (2+1)

Objective

To appraise the students with advanced techniques in handling of different bio-agents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.

Theory

Block 1: Different approaches in biological control

Unit 1: Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents vis-aÌ-vis target pest populations.

Block 2: Mass production technologies for bio agents

Unit 1: Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio-agents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

Block 3: Bio ecology of natural enemies

Unit 1 : Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of bio-control agents, bankable project preparation.

Block–4: Genetically engineered bio agents and microbes

Unit 1: Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in bio- control agents for introgressing and for progeny selections, breeding techniques of bio-control agents.

Practical

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semio- chemicals on natural enemies, breeding of various bio-control agents, performance of efficiency analyses on target pests; project document preparation for establishing a viable mass-production unit / insectary; observation of feeding behavior acts of predatory bugs/ beetles.

References

- Burges, H. D. And Hussey, N. W. (Eds.), 1971, Microbial Control of Insects and Mites. Academic Press, London.
- Coppel, H. C. And James, W. M., 1977, Biological Insect Pest Suppression. Springer Verlag, Berlin.
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- Huffakar, C. B. And Messenger, P. S., 1976, Theory and Practices of Biological Control. Academic Press, London.

ENT 606 INSECT TOXICOLOGY AND RESIDUES (2+1)

Objective

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

Theory

Block 1: Novel insecticides & new pest management approaches

Unit 1: Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Developments in bio-rational approaches; SPLAT; RNAi technology for pest management.

Unit 2: Biochemical and physiological target sites of insecticides in insects; Biopesticides, newer molecules; their modes of action; metabolism of insecticides.

Unit 3: Joint action of insecticides; activation, synergism and potentiation.

Block 2: Problems associated with pesticides

Unit 1: Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

Unit 2 : Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues; insecticide laws and standards, and good agricultural practices.

Practical

Phytotonic and phytotoxic action insecticides, Assessment of field efficacy of insecticides, toxicity of insecticides on beneficial insects, biochemical and biological techniques for detection of insecticide resistance in insects, visit to pesticide residue laboratory.

References

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ENT 607 PLANT RESISTANCE TO INSECTS (1+1)

Objective

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

Theory

Block 1: Plant biochemical resistance to Insects

Unit 1: Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species - gene pool; insect sources – behaviour in relation to host plant factors.

Unit 2: Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

Block 2: Biotechnological approaches in Plant resistance

Unit 1: Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

Block 3: Plant V/s inset resistance

Unit 1: Estimation of plant resistance based on plant damage-screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

Practical

Understanding mechanisms of resistance for orientation, feeding, oviposition etc., allele chemical bases of insect resistance; macroculturing of test insects like aphids, leaf/plant hoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

References

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- Rosenthal, G. A. And Janzen, D. H. (Eds.), 1979, Herbivores - their Interactions with Secondary Plant Metabolites. Vol. I, II. Academic Press, New York.
- Sadasivam, S. And Thayumanavan, B., 2003, Molecular Host Plant Resistance to Pests. Marcel Dekker, New York.

ENT 608 ACAROLOGY (1+1)

Objective

To acquire a good working knowledge of identification of economically important groups of mites up to the species level, a detailed understanding of the newer acaricide molecules and utilization of predators.

Theory

Block 1: Major families and orders of Acari and their management

Unit 1: Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnidae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

Unit 2: Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

Block 2: Acaricides and their mode of action

Unit 1: Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

Block 3: Mass production of predatory mites and pathogenic fungi

Unit 1: Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi- identification, isolation and utilization.

Practical

Identification of commonly occurring mites up to species, preparation of keys for identification. Collection of specific groups of mites and preparing their identification keys. Rearing phytoseiid mites and studying their role in suppression of spider mites. Management of mite pests of crops using acaricides, phytoseiid predators, fungal pathogens etc.

References

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- KRANTZ, G. W., 1970, A Manual of Acarology. Oregon State University Book Stores, Corvallis, Oregon.
- SADANA, G. L., 1997, False Spider Mites Infesting Crops in India. Kalyani Publ. House, New Delhi.

ENT 609 MOLECULAR ENTOMOLOGY (1 + 1)

Objective

To familiarize the students with DNA recombinant technology, marker genes, transgenic plants, and biotechnological advances in insect science.

Theory

Block 1: Molecular biology and techniques

Unit 1: Introduction to molecular biology; techniques used in molecular biology.

Block 2: Genetic engineering and its applications in insect science

Unit 1: DNA and RNA analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, Bt and entomopathogenic fungi.

Block 3 Transgenics in Entomology

Unit 1: Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTi; lectins and proteases. Transgenic plants for pest resistance and diseases.

Block 4: Applications of biotechnological tools in Entomology

Unit 1: Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.

Unit 2 : DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

Practical

Isolation of DNA/RNA; purity determinations, purification of total DNA from animal tissues; base pair estimation; agarose gel electrophoresis; enzyme assay ; demonstration of PCR, RFLP and RAPD techniques.

References

- BHATTACHARYA, T. K., KUMAR, P. AND SHARMA, A., 2007, Animal Biotechnology. 1st Ed., Kalyani Publication, New Delhi.
- HAGEDON, H. H., HILDERBRAND, J. G., KIDWELL, M.G. AND LAW, J. H. 1990, Molecular Insect Science. Plenum Press, New York.
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- ROY, U. AND SAXENA, V., 2007, A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publ., New Delhi. Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publ., New Delhi.
- SINGH, P., 2007, Introductory to Biotechnology. 2nd Ed. Kalyani Publ., New Delhi.

ENT 610 INTEGRATED PEST MANAGEMENT (2+0)

Objective

To acquaint the students with recent concepts of integrated pest management; surveillance and data base management; successful national and international case histories of integrated pest management, non- conventional tools in pest management.

Theory

Block 1: Data base management in Integrated Pest Management

Unit 1: Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modelling.

Block 2: Success stories and Knowledge based Pest management

Unit 1: Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.

Block 3: Genetic and ecological based pest management

Unit 1: Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.

Block 4: Challenges and new vistas in pest management

Unit 1: Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

References

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- FLINT, M. C. AND BOSCH, R.V. 1981, Introduction to Integrated Pest Management. Springer, Berlin.

- KOUL, O. AND CUPERUS, G. W. 2007, Ecologically Based Integrated Pest Management. CABI, London.
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- SUBRAMANYAM, B. AND HAGSTRUM, D. W., 1995, Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

Ph.D. in Forestry and Environmental Science

Course Code	Course Title	Credit Hours
FES 601	Bioremediation	2 (1+1)
FES 602	Advances in Forest Genetics Resources and Tree Breeding	2 (1+1)
FES 603	Industrial Wastes - Impacts on Agro-Ecosystem	2 (1+1)
FES 604	Advances in Agro-Forestry Systems and Management	2 (2+0)
FES 605	Green Technologies and Environmental Protection	2 (1+1)
FES 606	Advances in Forest Regeneration	2 (1+1)
FES 607	Advances in Silviculture	2 (2+0)
FES 608	Kinetics of Waste Water Treatment	2 (1+1)
FES 609	Climate Change: Consequences and Mitigation Strategies	2 (1+1)
FES 610	Recycling of Wastes: Soil and Microbial Processes	2 (1+1)
FES 611	Advances in Tropical Ecology	2 (1+1)
FES 612	Forest Ecosystem Services and Livelihood Benefits	2 (1+1)
FES 613	New Tools In Conservation and Field Ecology	2 (1+1)
FES 614	Ethno-biology and Tribal welfare	2 (1+1)
FES 615	Advanced Wildlife Management	2 (1+1)
	Total	**30 (17+13)**
FES 680	Qualifying Examination	3 (0+3)
FES 681	Seminar -I	1 (0+1)
FES 682	Seminar - II	1 (0+1)
FES 683	Teaching Assistantship -I	1 (0+1)
FES 684	Teaching Assistantship - II	1 (0+1)
FES 691	Research -I	18 (0+18)
FES 692	Research -II	18 (0+18)
FES 693	Research -III	18 (0+18)
FES 694	Research -IV	18 (0+18)

FES 601 **BIOREMEDIATION** **(1+1)**

Objective

The goal of bioremediation is to atleast reduce pollutant levels to undetectable, nontoxic or acceptable level, that is, to within limits set by regulatory agencies or, ideally, to completely mineralize organo pollutants to carbon dioxide.

Theory

Block 1: Bioremediation

Unit 1- Introduction, concept and types of bioremediation.

Unit 2 - Advantages and disadvantages

Unit 3 - Principles and Processes of Bioremediation

Unit 4 - Bioremediation in soil- influence of soil properties on organic contaminants and bacteria

Unit 5 - Bioremediation of hydrocarbon: Biodegradation of BTEX hydrocarbons under anaerobic conditions - Petroleum contamination.

Block 2: Bioremediation of contaminated soil

Unit 1- Environments contaminated by polycyclic aromatic hydrocarbons nitro aromatic compounds.

Unit 2 - Bioremediation of heavy metals and microbial remediation of metals.

Unit 3 - Bioremediation for industrial wastes: Bioremediation of contamination due to industrial.

Unit 4 - Wastes disposal, tannery effluent, paper and pulp effluent – mine dump site.

Unit 5- Molecular techniques: Molecular techniques in bioremediation.

Practical

Site selection process for bioremediation - characterization of the selected sites - process identification and up-gradation for specific wastes - Bioremediation of specific tasks - ground water contamination due to nitro-aromatics, metals, chromium and their bioremediation. Remediation of land and water contaminated by paper factory effluent - Micro, Algal and phyto-remediation techniques.

References

- BIOREMEDIATION: Deok Manual for the Environmental professional (Advances in Environmental Control Technology by Dennis)
- ENVIRONMENTAL BIOTECHNOLOGY-Biodegradation, Bioremediation & Bioconversion.
- FULKAR, M.H., Bioremediation technology :Recent Advance
- GUPTA, P. H., Biotechnology and Genomics Rastogi Publication
- SHARMA, P. D., A textbook of Ecology & Environment. Rakesh Kumar Rastogi for Rastogi Publication Meerut.

FES 602 ADVANCES IN FOREST GENETIC RESOURCES AND TREE BREEDING (1+1)

Objective

Tree improvement refers to the application of forest genetics principles within a given silvicultural system for the purpose of improving the genetic quality of forest. Its goal is to improve the genetic value of the population while maintaining genetic diversity.

Theory

Block 1: Forest genetic resource conservation

Unit 1 - Forest genetic diversity

Unit 2 - Genetic structure of forest populations

Unit 3 - Genetic erosion : Assessment of genetic diversity

Unit 4 - Effect of sampling on genetic diversity

Unit 5 - Factors influencing levels of genetic diversity in woody

Unit 6 - Conservation of genetic diversity: gene and population conservation.

Unit 7 - *In situ* and *ex situ* conservation techniques.

Block 2: Breeding methodologies of forest species

Unit 1- Conventional breeding techniques

Unit 2 - Breeding techniques for forest species

Unit 3 - Problems and difficulties breeding of forest species

Unit 4 - Tree breeding for specific traits such as secondary metabolites

Unit 5 - Advanced techniques- MAS, population selection

Unit 6 - Prospects of tree breeding: advantages and difficulties

Unit 7 - Natural variation as a basic tool for breeding trees

Unit 8 - Provenance variations: definition of provenances, delineation of provenances, G x E interactions.

Block 3: Methods of tree breeding

Unit 1 - Conventional and advanced

Unit 2 - Mating designs

Unit 3 - Hybridization as special techniques for trees

Unit 4 - Hybrid evaluation using seedling population, merits and demerits

Unit 5 - Progeny testing: GCA, SCA, genetics and combining abilities

Unit 6 - Seed, clones, pedigree selection.

Unit 7 - Vegetative propagation of trees: methods and clonal orchards

Practical

Synchrony and asynchrony in mating populations; studying genetic variation within and among populations, Estimation of genetic parameters of few traits. Modelling genetic drift, data collection and analysis of heritability, seedling diversity, Visit to species provenances, seed and clonal orchards. Vegetative multiplication.

References

- ASHWANI, K., 2016.Advances in Tree Improvement and Forest Genetic Resources Conservation and Management. Jain Publishers, ISBN:8181089286
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- PALANISAMY, K., KRISHNA, K. N. AND ANANDA LAKSHMI, R., 2012, Forest Genetic Resources Management in India. Jain Publication, ISBN:9788190034654.

FES 603 INDUSTRIAL WASTES - IMPACT ON AGRO-ECOSYSTEM

(1+1)

Objective

The overall objectives of the waste management assessment to assess the activities involved for the proposed and determine the type, nature and estimated volumes of waste to be generated. To identify any potential environmental impacts from the generation of waste at the site.

Theory

Block 1: Industrial waste

Unit 1 - Characteristics of wastes

Unit 2 - Major polluting industries in India and Karnataka

Unit 3 - Over view of tannery, textile, paper and pulp, sugar and distillery and characteristics of wastes

Unit 4 - Air pollution and its effect

Unit 5 - Types and sources of pollutants: gases, smokes, particulate matters

Unit 6 - Composition of polluted air in industrial sites

Unit 7 - Soil acidification and biological indicators of air pollution

Unit 8 - Effect on agricultural and human health

Unit 9 - Effects of fluorides on plant growth and forage quality .

Block 2: Wastewater and crop production

Unit 1 - Impact of industrial waste water on soil, crops and human health

Unit 2 - Utilization of solid wastes in agriculture

Unit 3 - Types and characteristics of solid wastes

Unit 4 - Current disposal methods

Unit 5 - Solid waste management – composting, utilization, recovery by recycling

Unit 6 - Bio-absorption of heavy metals present in waste water

Unit 7 - Thermal pollution and environmental quality standards

Unit 8 - Sources, causes in water bodies and their consequences on metabolic activities of organisms

Unit 9 - Impacts on agro ecosystem and human health and its control

Practical

Effect of air pollutants on agro - ecosystems - soil and water - impact on plant, microbial and animal metabolisms - heavy metal pollution (Chromium, Lead, Mercury, Cadmium) - effect on soil health and agricultural crops - selection of tolerant crops and varieties - wastewater reuse and its implications on agro ecosystems. Solid wastes recycling - use of solid wastes in agriculture - long term effect on cropping systems. Assessment of the effect of specific industrial wastes on agricultural land and crops. Development of treatment process for specific wastes by enrichment and acclimatization.

References

- ABHISKEH R. AND MANOJ, K., Climate Change and Agro forestry Ecosystems, Adaptation and Mitigation Measures, Apple Academic Press. CRC, Press.
- CHAUBEY, O. P., VIJAY, B. AND SHULA, P. K., 2016, Sustainable Rehabilitation of Degraded Eco-systems Gurupreet Sing & Surinder Kaur, Agro-Industrial Wastes as Feedstock for Enzyme Production, Academic press.
- EMILIA,Z.A.,SARVA,M.P.,SHARIFAH,N.S. AND UMI,R. A.R.,2019, The Harmful Effects Of Waste Leachate To Fish And Human.
- JOHN, P.S. A., Industrial Waste: Environmental Impact, Disposal and Treatment UK ed. Edicióncde.
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FES 604 ADVANCES IN AGRO-FORESTRY SYSTEMS AND MANAGEMENT (2+0)

Objective

To manage land efficiently so that its productivity is increased and restored. To generate employment opportunities for rural peoples. To provide raw material for small cottage industries in rural areas. To raise the supply of fuel in the rural areas at convenient distance for consumer.

Theory

Block 1: Advances in Agro - forestry management

Unit 1- Emphasis on live fences, boundary plantings, hedge row intercropping

Unit 2 - Mixed intercropping, fodder banks, woodlots

Unit 3 - Experimental designs for Agro-forestry management

Unit 4 - Costs and benefits in Agro-forestry; Environmental outputs

Unit 5 - Discounting rates for private and public economic analysis.

Block 2: Methodology for the exploration of multipurpose trees in Agro-Forestry

Unit 1 - General considerations & collection of MPTs

Unit 2 - Assessment and choice of experimental sites

Unit 3 - Assessment of methodologies of multipurpose trees in Agro-forestry

Unit 4 - Changes in plant species; Tree/crop interface approach

Unit 5 - Systematic designs; Bivariate analysis for intercropping experiments.

Unit 6 - Modelling in Agro-forestry and their elements

References

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- MOHAN, K. B. AND RAMACHANDRAN, P. K., 2011, Carbon Sequestration potential of Agro-forestry Systems: Opportunities and Challenges. Springer Publisher, ISSN18751199 & ISBN978-94-007-1629-2.
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Systems. International Book Distributing Co, ISBN-13:9788181891891.

FES 605 GREEN TECHNOLOGIES AND ENVIRONMENTAL PROTECTION (1+1)

Objective

The goal of green tech is to protect the environment, repair damage done to the environment in the past, and conserve the Earth's natural resources.

Theory

Block 1: Agricultural productivity

Unit 1 - Agricultural productivity and area of cultivation

Unit 2 - Nutrient requirement for major crops

Unit 3 - Nutrient loss and pollution in water and land

Unit 4 - Types of plant protection chemicals and weedicides used

Unit 5 - Impact on land and water and biological system.

Block 2: Green technologies:

Unit 1 - Definition, objectives, approach and types

Unit 2 - Alternate source for plant nutrients – Biomanure, Vermicompost, Bio - fertilizers plant growth promoting Rhizobacteria (PGPR)

Unit 3 - Organic agriculture - concepts and prospects

Unit 4 - Organic inputs for healthy cultivation - Green leaf manure

Unit 5 - Plant protection measures – Biopesticides – Biocontrol agents - Trap crop for pest control

Block 3: Ecosystem management

Unit 1 - Water management

Unit 2 - Ecologically balanced exploitation of soil, water and air resources.

Unit 3 - Waste utilization.

Unit 4 - Waste recycling: Composting technology for organic waste recycling.

Unit 5 - Biogas production from solid and liquid waste

Practical

Integrated farming system - Water conservation techniques - Compost making – Vermi compost preparation - PGPR organism usage - Bio pesticide usage - Bio control agents handling and usage - Eco friendly fruits and vegetable production - Integrated pest management.

References

- ALAIN, A., VERTESNASIB, Q.H. AND HIDEAKI, Y.B. C., 2020. Green Energy to Sustainability: Strategies for Global Industries. John Wiley Publication, ISBN: 9781119152026.
- ENOCH, Y., PARK. TAKAYUKI, S., HIROKAZU K. AND MASAKAZU, H., Green Science and Technology. Taylor & Francis Ltd Publisher, ISBN:9780367415136
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- XAVIER, S. AND USHARAO, S. J., 2021. Go Green for Environmental Sustainability an Interdisciplinary Exploration of Theory and Applications. Taylor & Francis Ltd Publisher, ISBN: 9780367517403

FES 606 ADVANCES IN FOREST REGENERATION (1+1)

Objective

Reproduction or regeneration of forest crop is an essential condition for the practice of scientific forestry, as failure or under-performance on this score will disrupt the sustainability of forest yield. Objective of natural regeneration is the renewal of a forest crop by self-sown seeds or by coppice or root suckers.

Theory

Block 1: Forest regeneration

Unit 1 - Principles and methodologies of forest regeneration

Unit 2 - Ecological basis of natural regeneration techniques

Unit 3 - Tree regeneration and its evolutionary trend

Unit 4 - Ecological status of woody plants

Unit 5 - Choice of species for various sites

Unit 6 - Regeneration sampling pattern and intensity

Block 2: Factors affecting natural and artificial regeneration

Unit 1 - Kinds, extent and quality of sites

Unit 2 - Relationship of soil characteristics like nutrient, moisture, structure and physiography with tree growth and site productivity

Unit 3 - Site manipulation by physical chemical and biological methods.

Unit 4 - Regeneration in relation to silvicultural systems.

Unit 5 - Problems of regeneration in respect of important conifers and broad leaved.

Practical

Monitoring of forest regeneration, choosing a regeneration method, preparation of regeneration plans, factors promoting natural regeneration, sampling method and accessing success or failure of regeneration, modern approaches in container seedling production, INM and irrigation in quality seedling production, studies on the regeneration techniques of timber and pulpwood species, cost benefit analysis of regeneration methods.

References

- ANITA, R.M., 1995.Forest Resources Conservation and Regeneration. Concept Publishing Company Pvt. Ltd.
- GOMEZP. A. WHITMORE, T.C.AND HADLAY, M., Rain Forest Regeneration and Management. Taylor & Francis.ISBN1850702616
- MARY, L.D. AND PHILIP, M.D., 1991, Forest Regeneration Manual. Springer Publication

FES 607 ADVANCES IN SILVICULTURE (2+0)

Objective

The main object of silviculture is to provide maximum protection to the site so that intangible returns from the forests are ensured

Theory

Block 1: Silviculture

Unit 1 - Philosophy of silviculture

Unit 2 - Advance reproduction methods and their role in silviculture

Unit 3 - Judging successful establishment

Unit 4 - Analysis of active and passive site preparation

Unit 5 - Silviculture with an ecosystem approach

Block 2: Advance silvicultural practices

Unit 1 - In rain forest; Tropical forest; Subtropical forest, Temperate forest

Unit 2 - Mechanization and role in Silviculture

Unit 3 - Analysis of different techniques of silviculture in forest stand management

Unit 4 - Technique for early stand development

Unit 5 - Analysis of thinning methods and its impact on wood yield and quality

Unit 6 - Stand protection and health management

Unit 7 - Advances in coppice silviculture

Unit 8 - Adjusting silviculture to meet industrial demands

References

- KENNETH, R.S., 2020.Plantation Silviculture. Springer Nature(Sie) Publisher
- PANWAR, P, AND BHARDWAJ, S. D., Handbook of Practical Forestry
- RALPH, C.H. AND DAVID, M., Practice of Silviculture. Smith Publication, ISBN0471800171
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FES 608 KINETICS OF WASTE WATER TREATMENT (1+1)

Objective

The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment.

Theory

Block 1: Kinetics of Waste water treatment system

Unit 1 - Factors affecting treatment - microbial growth kinetics – enzymes and enzyme kinetics

Unit 2 - Microbial kinetics of nitrogen, phosphorous and sulphur removal in waste water

Unit 3 - Characterization of waste waters

Unit 4 - Quality of various industrial effluents

Unit 5 - Sources of pathogens, human risks

Unit 6 - Pollution of fresh water and estuaries

Unit 7 - Fundamentals of waste water treatment technologies

Unit 8 - Measurement of purification- insoluble materials, soluble matter, concept of oxygen demand

Unit 9 - Test for biologically degradable organic matter.

Block 2: Methods of waste water treatment

Unit 1 - Aerated lagoons, oxidation ditches and stabilization ponds

Unit 2 - Activated sludge, microbial community in activated sludge

Unit 3 - Aerobic digestion, trickling filters, rotating biological contactors

Unit 4 - Nitrification biological fluidized bed reactors for treatment of sewage and Industrial effluents

Unit 5- Anaerobic digestion and anaerobic contact process, denitrification, fluidized bed anaerobic reactors

Unit 6 - Anaerobic down flow stationary fixed film reactors

Unit 7 - Applications of waste water treatment

Practical

Analysis of waste waters for the prevalence of pathogenic organisms - Treatment of waste waters by aerobic and anaerobic methods: aerated lagoons and trickling filters - interaction studies on different microbial communities in different effluent treatment methods Land disposal of waste water - Effect of effluent irrigation on physical, chemical and microbiological properties of soil and plant growth. Visit to common effluent treatment plants - tannery - dyeing industry - Pulp and paper mill.

References

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- ANONYMOUS 1980 Standard Methods for Examination of Water and Waste Water American Public Health Association (5th Ed).

- ANONYMOUS 1974 Physico-Chemical Process for Water quality, Weber. W.J, Ann Arbor and company, New Delhi.
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FES 609 CLIMATE CHANGE: CONSEQUENCES AND MITIGATION STRATEGIES (1+1)

Objective

Main objective is to improve awareness and understanding of climate change amongst citizens. The objective of mitigation is to minimize loss of life and property from natural hazard events.

Theory

Block 1: Climate change

Unit 1 - Recent developments in global climate change

Unit 2 - Changes in source and sinks of carbon in the last few decades

Unit 3 - Global warming potential of major GHG's

Unit 4 - Relevant mitigation measures to address these issues

Unit 5 - Effect of climate change on Ocean, Soil, Forest and Biodiversity

Unit 6 - Agriculture & livelihood and relevant mitigation measures to address these issues.

Block 2: Climate change

Unit 1 - Economic development and energy conservation dilemma

Unit 2 - Role of alternate energy sources and its current status towards offsetting fossil fuel use.

Unit 3 - Carbon footprint: concepts and methods of assessment.

Unit 4 - Applications and its uses in different fields with special reference to Agriculture.

Unit 5 - Role of Agro - forestry: strategies to increase terrestrial carbon sink, Global dimming.

Unit 6 - Role of aerosols in global dimming and implications to solar energy constant.

Block 3: Policy issues

Unit 1 - Kyoto protocol

Unit 2 - Carbon trading mechanisms

Unit 3 - Montrial agreement & Marrakish accord

Unit 4 - REDD, REDD+ and other recent international agreements and negotiations to address the climate change issues

Unit 5 - Other climatic aberrations and its relationship to climate change

Unit 6 - Ozone depletion, ENSO, *etc*

Unit 7 - India's stand on climate change: Recent developments in the strategies; Green India Mission & CAMPA.

Unit 8 - Millennium goal and other policy initiatives to mitigate climate change.

Practical

Atmospheric CO_2 measurement methods. Soil carbon assessment. Soil carbon dynamics. Atmospheric CO_2 flux measurements. Exposing plants to elevated CO_2 concentration. FACE and FATE experiments, Open top chambers and its importance in understanding the effect of increased CO_2 concentration on plant growth. Differential response of species to elevated CO_2 concentrations. Diurnal plant response to light, temperature and CO_2 concentrations.

References

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FES 610 RECYCLING OF WASTES: SOIL AND MICROBIAL PROCESSES (1+1)

Objective

Recycling helps protect the environment. Recycling reduces the need for extracting, refining and processing raw materials all of which create substantial air and water pollution. As recycling saves energy, it also reduces greenhouse gas emissions, which helps to tackle climate change.

Theory

Block 1: Recycling of wastes

Unit 1 - Composting - Basic concepts - Clean compost production - Evaluation of compost for stability

Unit 2 - Types of composting: Yard waste composting, Sludge composting, Vermi composting, Low tech composting for small volumes

Unit 3 - Composting process: Environmental factors, Microbiology, Biochemistry, humus formation

Unit 4- Aerobic composting process - advantages and disadvantages

Unit 5 - Anaerobic composting- advantages and disadvantages.

Block 2: Compost Assessment

Unit 1 - Assessing compost maturity

Unit 2 - Phytotoxicity, organic compounds, trace elements, heavy metals

Unit 3 - Micronutrients, odour and volatile organic compounds

Unit 4 - Elements of odour management, standards for compost

Unit 5 - Compost and environmental management

Unit 6 - Environmental consequences – pathogens, bioaerosols, soil physical and chemical manifestations

Unit 7 - Biofiltration - concepts and approaches to regulation.

Unit 8 - Utilization of compost for crop cultivation.

Unit 9 - Industrial solid wastes recycling

Practical

Collection process for organic wastes - sludges - selection of methods of analysis - isolation techniques for elite organisms - low cost technology for waste recycling - maturity test for composting - composting - standardization of the process - sludges - metal decontamination - study of odour causing compounds - management.

References

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- GREGA, M.D., BUCKINGHAM, P. L. ANDEVANS, J. C., 2001 Hazardous Waste Management, IIEd, Mc Graw Hill Inc.,
- LIE, D.H.F.AND LIPTAK, B.G., 2000, Hazardous Wastes and Solid Wastes-Lewis publishers, New York.
- MILARY, T. AND SAMUEL, A.V.,1993, Solid waste management - George Tehobanaglous-Integrated, Mc Graw Hill Inc,

FES 611 ADVANCES IN TROPICAL ECOLOGY (1+1)

Objective

Both terrestrial and aquatic tropical ecosystems provide critical ecological services that humans, no matter where they live on this planet, depend upon. For example, tropical forests affect the global carbon cycle and via carbon sequestration (photosynthesis) store up to 50% of all terrestrial carbon.

Theory

Block 1: Introduction on Tropical ecology

Unit 1 - Introduction to the ecological complexity of tropical forests

Unit 2 - Evolutionary processes of species co-existence

Unit 3 - Causes of the origin of tropical species diversity.

Unit 4 - Present day ecological factors affecting the distribution of tropical organisms (climatic and topographic heterogeneity).

Unit 5 - Biological interactions – herbivory, seed dispersal, pollination, co-evolution

Unit 6 - Monitoring plans to assess potential ecological impacts.

Block 2: Functions of Tropical forest

Unit 1 - Nutrient cycling

Unit 2 - Regeneration and response to disturbances

Unit 3 - Physiological characteristics of tropical plants

Unit 4 - Threats to Biodiversity

Unit 5 - Current threats to tropical biodiversity in the "Era of Globalization" and tourism boom including habitat fragmentation, ecological impacts derived from agricultural and urban sprawling, climate change, and consequences for the dynamics of tropical species

Unit 6 - Developing strategies to minimize negative impacts on tropical ecosystems, including restoration ecology, organic agriculture, design of biological reserves and corridors for forest connections

Practical

Assessment of different ecosystems for species assemblage and co-existence. Evaluation of climatologically components for species assemblage. Evaluation of local stresses and its impact on regeneration and species composition. Assessment of biotic and abiotic factors on ecosystem interaction. Assessment of climate change on ecosystem in terms of growth responses. Assessment of leaf litter influence on soil physico - chemical components. Impact of forest fragmentation on species dispersion, migration and composition. Phenological and morphological changes on the species.

References

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- OSBORNE, P.L., 2012 Tropical Ecosystems and Ecological Concepts. Cambridge University Press.

FES 612 FOREST ECOSYSTEM SERVICES & LIVELIHOOD BENEFITS (1+1)

Objective

Healthy forest ecosystems produce and conserve soil and stabilize stream flows and water runoff - preventing land degradation and desertification and reducing the risks of natural disasters such as droughts, floods and landslides.

Theory

Block 1: Forest ecosystem services

Unit 1 - Concepts and approaches.

Unit 2 - Biodiversity as bio-resources.

Unit 3 - Role of forests resources in human civilization: During Easter Island, Indian empires.

Unit 4 - NTFP, Medicinal plants, economically useful plants as bio-resources for human civilization.

Unit 5 - Forest as livelihood sources; human dependency on forest.

Unit 6 - Forest – Agricultural interrelations.

Unit 7 - Forest as sources as agricultural inputs (tangible and non-tangible).

Block 2: Eco - system services

Unit 1 - Tangible and non-tangible, environment.

Unit 2 - Health including water, oxygen, flavor and medicines.

Unit 3 - Pollination services and fertile blooms, predators and parasites.

Unit 4 - Carbon fixation.

Unit 5 - Forest as source for industry: Genetic resources for biotechnology.

Unit 6 - BT genes and other micro organisms.

Unit 7 - Pharma industry, neutral industry, food industry and others.

Unit 8 - Key stone services: key stone species (Ficus, long horned Bill), key stone relations ex; Ficus-wasp symbiosis

Practical

Assessing contributions of NTFP, medicinal plant and economic plants from a given forest. Data collection on forest dwellers, survey on their dependence. Study of Agril-Forest interface and assessing the exchange of genetic and biodiversity. Observations on pollinators and range wild species dependant on pollination. Assessing the diversity of parasites and predators in a given patch of forest. Carbon assessment in forest ecosystem. Visit to bio-prospecting lab Introduce bio-resource to product generation. Studying key stone relationships.

References

- JAGADISH, C. D., ANIL, K.S.AND AYYANANDAR, A., 2019, Agroforestry Systems in India: Livelihood Security & Ecosystem Services. Springer, India, Private Ltd Publication, ISBN:9788132216612
- JURGEN, B., PETER, V.D.M. AND MARKKU, K., Ecosystem Goods and Services from Plantation Forests. Taylor & Francis Ltd Publication, ISBN:9781138993303
- KAPIL, K., DALIP, K. M. AND BHUPENDRA, S.B., 2022, Wild Plants Used as a Forest Ecosystem Services by the Local Inhabitants of Champawat District of Uttarakhand to the Subsistence of Their Livelihood. IGI Global Publishers.
- SUJANA, K. A., 2016, Forest ecosystem (Biodiversity, Ecology and Conservation). Write and print publications, ISBN:9789384649616

FES 613 NEW TOOLS IN CONSERVATION AND FIELD ECOLOGY (1+1)

Objective

Extinct species require care and habitation and efforts must be made to prevent them from becoming extinct. As a result, the primary goal of conservation is to protect natural resources, forests, wildlife, plants and biodiversity.

Theory

Block 1: Conservation

Unit 1 - Conservation Top - Down (TD) and Bottom - Up (BU) approaches

Unit 2 - Concept: Defining the TD and BU

Unit 3 - Gene- Ecosystem and Ecosystem to Genes

Unit 4 - Advantages and disadvantages, combining the two approaches

Unit 5 - *In situ* conservation: Concept

Unit 6 - Traditional concept, altered views, advantages, disadvantages, relevance to forest species

Unit 7 - Methodology: Forest gene Banks, steps involved in Forest gene banks

Unit 8 - Mapping viable populations, assessing genetic diversity and polymorphism of populations

Unit 9 - Identifying source populations and donor populations, strategies to create gene corridors.

Block 2: Species Recovery Programmes

Unit 1 - Identifying species for recovery

Unit 2 - Identifying the niches for recovery

Unit 3 - Identifying sources populations for replenishing based on genetic diversity

Unit 4 - Production of propagules and replenishing the habitats

Unit 5 - Monitoring the establishment.

Unit 6 - *Ex-situ* Conservation

Unit 7 - Traditional methods: seeds, pollen, tissue.

Unit 8 - New Methods: DNA, Organells *etc*.

Unit 9 - Techniques involved

Block 3: Field techniques in forest enumeration

Unit 1- Stratifying using NDVI data

Unit 2 - Locating and laying transects, nested plots for various habits

Unit 3 - Enumeration and data collection

Unit 4 - Computerizing the data and organizing

Unit 5 - Mapping and assessing the resource status

Practical

Tools for top down (TD) approach: Spatial mapping tools, Ecosystem stratification based on topography, Biological and cultural layers; Tools for Bottom up (BU): approach assessing and mapping genetic diversity, Biotech tools, identifying genetic diversity hotspots. Combining the two approaches: weighing the layers and combining them.

References

- KORMONDAY, E.J., 2017, Concepts of Ecology. Pearson Press.
- MAGURRAN, A. E., 1988, Ecological Diversity and Its Measurement. Croom Helm, London
- MUELLER, D. AND ELLENBERG, H., 1974, Aims and Methods in Vegetation Ecology. John Willey & Sons, New York.
- RICHARDS, P.W., 1996, The Tropical Rain Forest: An Ecological Study. Cambridge University Press

FES 614 ETHNOBIOLOGY AND TRIBAL WELFARE (1+1)

Objective

To eradicate the exploitation and develop the remote areas. To improve the life there by providing adequate health and educational services. To provide physical and financial security against any kind of oppression and exploitation.

Theory

Block 1: Ethnobiology

Unit 1- Definition, definition of tribe, cultural traditions, customs, ethos, beliefs and practices

Unit 2 - Important tribes of India

Unit 3 - Important tribes of Karnataka

Unit 4 - Interdependence with forests, role of NWFP in the life of tribes.

Unit 5 - Tribes and forest policies

Unit 6 - Rights and concessions and fall out

Unit 7 - Constitutional safeguards for the welfare of tribes

Block 2: Role of tribes in forest and potential area management.

Unit 1- Tribal development schemes and problems in implementation

Unit 2 - Legal provisions to safeguard tribal interests

Unit 3 - Ethnic conflicts between tribes and non tribes

Unit 4 - Voluntary organizations and tribal development

Unit 5 - Tribals and JFM, Indigenous knowledge and tribal development

Unit 6 - Ethnomedicinal practices and traditional wisdom

Unit 7 - Shifting cultivation and tribes

Unit 8 - Tribes and forest development works

Unit 9 - Eco - development through tribal development

Unit 10 - Case study of Bandipur/Nagarahole Reserves. Human rights and tribes.

Practical

Visit to different tribal colonies to understand problems faced by them, Conduct surveys to evaluate the life standards. Visit to different development organizations and NGO's implementing tribal welfare schemes and study about research aspects of Indian tribes. Visit to Vana Samrakshana Samiti (VSS) of tribes and understand their role in forest management.

References

- JAIN, S.K. AND MUDGAL, V., 1999, Handbook of Ethnobotany. M/s Bishen Singh Mahendra Pal Singh, Dehra Dun.
- JAIN, S.K.,2010, Manual of Ethnobotany ,2ND Ed. Scientific Publishers
- KUMAR, V., 2006, Tribal Welfare and Development in India. Anmol Publications Pvt. Ltd.
- PULLAIH, T., KRISHNAMURTHY, K. V. AND BAHADUR, B., (Eds.). 2018, Ethnobotany of India.Vol.5. The Indo-Gangetic Region and Central India. CRC Press.

FES 615 ADVANCED WILDLIFE MANAGEMENT (1+1)

Objective

Provide knowledge and first-hand experience of conservation issues and practices under varied ecological, socio-economic, political and administrative situations in the field including the vulnerability of species of wild plants and animals and their protection.

Theory

Block 1: Wildlife management

Unit 1 - History and conservation in India

Unit 2 - Zoo geographic regions of the world

Unit 3 - IUCN revised red list categories, Red Data Book and Red listing, Wildlife census, radio telemetry in wildlife studies.

Block 2: Captive wildlife: Zoos and safari parks.

Unit 1 - Captive breeding for conservation.

Unit 2 - Central Zoo Authority of India.

Unit 3 - Wildlife (Protection) Act, 1972.

Unit 4 - Special projects for wildlife conservation, Project Tiger and Musk Deer Project

Unit 5 - Captive breeding and reintroduction of threatened species - MAB, CITES, TRAFFIC.

Unit 6 : Protected area network of India: Wildlife Sanctuaries, National parks, Biosphere reserves.

Practical

Exercise on the census methods, use of soft ware for analysis of census data. Pitfall trap, mist net, Sherman trap, camera trap and other traps to study the wildlife

Reference

- HOSATTI, B. B., Concepts in Wildlife Management. Daya Publishing House.
- JOSHUA, M., FRANK, R. AND THOMPSON. 2008, Models for Planning Wildlife Conservation in Large Landscapes. Elsevier Science Publishing Co Inc.
- MANJPURIA. 1990, Wildlife Wealth of India: Resources & Management. Tec press Service Bangkok.
- SINGH, S. K., 2015, Wildlife Management in Indian. CBS Publishing.

Ph.D. in Food Science and Nutrition

Course Code	Course Title	Credit Hours
FSN 601	Macro Nutrient Metabolism	3 (3+0)
FSN 602	Metabolism of Vitamins and Hormones	2 (2+0)
FSN 603	Minerals in Human Nutrition	2 (1+1)
FSN 604	Advances in Food Science and Technology	2 (1+1)
FSN 605	Advances in Energy Metabolism	2 (2+0)
FSN 606	Nutrition and Agricultural Interface	2 (2+0)
FSN 607	Nutrition in Emergencies	1 (1+0)
FSN 608	Application of Biotechnology in food and nutrition	2(2+0)
FSN 609	Global Nutritional Problems	2 (2+0)
FSN 610	Maternal and Child Nutrition	2 (1+1)
	Total	**20 (17+3)**
FSN 680	Qualifying Examination	3 (0+3)
FSN 681	Seminar -I	1 (0+1)
FSN 682	Seminar - II	1 (0+1)
FSN 683	Teaching Assistantship -I	1 (0+1)
FSN 684	Teaching Assistantship - II	1 (0+1)
FSN 691	Research -I	18 (0+18)
FSN 692	Research -II	18 (0+18)
FSN 693	Research -III	18 (0+18)
FSN 694	Research -IV	18 (0+18)

FSN 601 MACRO NUTRIENT METABOLISM (3+0)

Objective

To give a strong theoretical base to the students with reference to metabolism of macro nutrients and to approach the related areas from a multi dimensional perspective.

Theory

Block 1: Advances in Macronutrients

Unit I: Macronutrient Metabolism

Carbohydrates, proteins and lipids-their digestion, absorption, metabolism. Inborn errors of metabolism. Metabolic disorders-diabetes, dental caries, obesity, atherosclerosis, hyperlipidemia and hypertension

Unit II: Glucose Homeostasis

Glucose homeostasis determined by insulin/glycogen ratio; carbohydrates free diet and its metabolic consequences; glycemic index

Unit III: Dietary Fibre

Dietary fibre-its definition, composition, classification, functions and role in various physiological disorders.

Block 2: Advances in Protein

Unit I: Classifications and functions of Proteins

Classification of protein, new discoveries in protein and their functions such as protein in Immune system, as lubricants, biological buffers and carriers.

Unit II: Evaluation of Protein Quality

Evaluation of protein quality: in vitro and in vivo methods, animal and human bioassays: amino acid pool, protein turn over in man with special reference to body size, age and various nutrition and pathological conditions, regulation of proteins, requirements; novel food sources of protein .

Unit III: Hormones on protein metabolism

Effect of insulin, cortico steroids, thyroids, and androgen and growth hormone on protein metabolism, in heritable disorders of amino acid metabolism of protein

Unit IV: Protein on certain metabolic diseases

Effect of dietary protein on cardio-vascular disease and cholesterol metabolism, adaptation of body to low intake of energy and protein

Blck 3: Advances in Lipids

Unit I: Classification and functions of lipids.

Classification and functions of lipids.

Unit II: Body fat components

Estimation of bodyfat; lipoproteins and hyper lipoproteinemia; hypo lipidemic action of PUFA omega-3 fatty acids and oxidation products of cholesterol

Unit III: Lipids in health and diseases

Lipids and cancer; fish oils in health and disease oxidative products of cholesterol. Disturbance in lipid metabolism, role of a diet in cardiovascular disorders; high blood cholesterol–causes, prevention and treatment; hypo lipidemic action of rice bran, oat, barley and legumes.

Practical

1-2: Assessment of protein quality.

3-8: Project work related to metabolic disorders of proximate principles.

9-12: Blood analysis in relation to NCD (Non Communication Diseases.

13-15: Estimation of amylase and protease inhibitors in foods.

References

- AKOH, C. C. AND MIN, D. B., 2002, Food Lipids - Chemistry, Nutrition and Biotechnology Marcel Dekker Inc. New York.
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- FAO WHO/UNU, 2007, Protein and Amino Acid Requirements in Human Nutrition: Report of a Joint FAO/WHO/UNU Expert Consultation, Geneva. Word Health Organization. Technical Report Series 935. http://www.who.int/iris/handle/10665/43411.
- NELSON, D. L. AND COX, M. M., 2017, Lehninger Principles of Biochemistry. 7th Edition. WH Freeman, New York.
- STIPANUK, M. H. AND CAUDILL, M. A., 2013, Biochemical, Physiological and Molecular Aspects of Human Nutrition. 3rd Edition. Elsevier Pub.

FSN 602 METABOLISM OF VITAMINS AND HORMONES (2+0)

Objective

To give understanding of the essentiality of vitamin sufficiency to aid metabolic processes in relation to health and disease on set and to equip the students with relevant knowledge of effective dietary management of a given disease condition due to hormonal imbalance.

Theory

Block 1: Advances in Vitamins

Unit I: Introduction

General definition and history of vitamins and hormones.

Unit II: Metabolism of Vitamins

Cause of vitamin deficiencies in India. Chronology, chemistry, distribution, functions, absorption, transport, metabolism, deficiency manifestations

Unit III: Requirements, assay and hypervitaminosis

Nutritional requirements, methods of assay. Interaction with other nutrients, antagonists and analogues of vitamins, Hypervitaminosis of water and fat-soluble vitamins; vitamin fortification and supplementation.

Block 2: Advances in Hormones

Unit I: Endocrine and exocrine Hormones

Endocrine and exocrine secretion of hormones; organs of secretion, metabolism, mechanism of action, regulation and sites of action, biological effects and interaction.

Unit II: Vitamins in metabolic disorders

Assessment of vitamin status of population; antioxidants and their relationship with aging, cancer and other metabolic disorders.

References

- GARLAND, C. F., GARLAND, F. C., GORHAM, E. D., LIPKIN, M., NEWMARK, H., MOHR, S. B. AND HOLICK, M. F., 2006, The Role of Vitamin D in Cancer Prevention. American Journal of Public Health. 96(2), 252–261.
- GROFF, J. L. AND GROPPER, S., 2012, Advanced Nutrition and Human Metabolism. 7th Edition, Yolanda Cossio, New York.
- GUARDIA, M. AND GARRIGUES, S., 2015., Hand Book of Mineral Elements in Foods. John Wiley & Sons Inc. Hoboken, New Jersey.
- RIZVI, S., RAZA, S. T., AHMED, F., AHMAD, A., ABBAS, S. AND MAHDI, F., 2014, The Role of Vitamin E in Human Health and Some Diseases. Sultan Qaboos University Medical Journal, 14(2), 157
- HENRY, H. L. AND NORMAN, A. W., 2014, *Hormones.* 3rd Edition. Academic Press, Cambridge.
- KLEINE, B. AND ROSSMANITH, W. G., 2016, *Hormones and the Endocrine System*. Springer Nature,
- SWITZERLAND NELSON, D. L. AND COX, M. M., 2017, *Lehninger Principles of Biochemistry*. 7th Edition. W.H. Freeman Company, New York.

FSN 603 MINERALS IN HUMAN NUTRITION (1+1)

Objective

To give an understanding of the essentiality of mineral sufficiency to aid metabolic processes in relation to health and disease on set and to enhance the knowledge of recent advances in mineral nutrition

Theory

Block 1: Introduction to Minerals

Unit I: Metabolism of minerals

General definition and history of minerals; causes of macro and micro mineral deficiencies in India. Chronology chemistry, distribution, functions, absorption, transport, metabolism, deficiency manifestations.

Unit II. Requirements and Assay

Nutritional requirements, methods of assay of all the minerals. Nutritional requirements, methods of assay of all the minerals. Interactions of minerals with other nutrients, antagonists and analogues of minerals.

Block 2: Minerals in Nutrition

Unit I: Assessment of Mineral Status

Assessment of mineral status of population, mineral fortification and supplementation;

Unit II: Harmful effects of minerals

Major mineral pollutants – their harmful effect on health mutagenicity, carcinogenicity.

Unit III: Mineral Isotopes

Use of mineral isotopes / tracers in nutritional studies.

Block 3. Metaloenzymes and Heavy metals

Unit I: Metaloenzymes, Antioxidants and their effects

Metaloenzymes; antioxidants and their relationshipwith aging, cancer and other metabolic disorders.

Unit II: Heavy Metal and trace minerals toxicity

Heavy metal toxicity; trace minerals, their chronology, chemistry, distribution, functions, absorption, metabolism, requirements, deficiency manifestation and interaction.

Practical

1-4: Assessment of antioxidants in foods;

5-10: Project to combat micronutrient deficiencies.

11-15:Vulnerable sections, Groups with special needs.

References

- JOHRI, P., Food and Nutrition series: mineral and water. Sonali Publications, New Delhi
- GROFF, J. L. AND GROPPER, S., 2012, Advanced Nutrition and Human Metabolism. 7th Edition, Yolanda Cossio, New York.
- GUARDIA, M. AND GARRIGUES, S., 2015, Hand Book of Mineral Elements in Foods. John Wiley & Sons Inc. Hoboken, New Jersey.
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FSN 604 ADVANCES IN FOOD SCIENCE AND TECHNOLOGY (1+1)

Objective

To acquaint the students with latest advances in food science and technology to meet nutritional challenges and to understand the integration of genomic science with nutrition.

Theory

Block 1. Advances in Food Science

Unit I: Advances in Nutrients

Recent advances in the field of carbohydrates, lipids, proteins, vitamins and minerals in relation to human nutrition.

Unit II: Nutrigenomics in diet

Nutrigenomics, in corporating genetics into dietary guidance.

Block 2. Food analysis and processing

Unit I: Advances in Food Analysis

Recent advances in the field of food analysis and food fortification. Foods of future; special nutrients.

Unit II: Advances in Processing and Product development.

Food processing and product development;

Unit III: Regulating Food Processing Guidelines

Regulating food processing and preservation through TQM and HACCP. GM foods and their health implications; functional foods and organic foods, impact of WTO in food regulation.

Practical

1-5:.Product development

6-10: Shelf life of nutritionally fortified foods using advanced technologies

11-15: Field study of food processing and preservation in relation to TQM and HACCP in an industry.

References

- HARTEL, R. W. AND HELDMAN, D., 2012, Principles of Food Processing. Aspen Publishers Inc. New York.
- WARD, J. D. AND WARD, L. T., 2012, Principles of Food Science. Goodheart-Willcox Publisher, Illinois.
- CLARK, S., JUNG, S. AND LAMSAL, B., 2014, Food Processing - Principles and Applications. 2ndEdition, Wiley-Blackwell Publishing Company, Boston.

- FELLOWS, P. J., 2017, Food Processing Technology. 4th Edition, Wood head Publishing Ltd. Cambridge.

5. DE MAN, J. M., FINLEY, J. W., HURST, W. J. AND LEE, C. Y., 2018, Principles of Food Chemistry. 4th Edition, Springer International Publishing, New York.

FSN 605 ADVANCES IN ENERGY METABOLISM (2+0)

Objective

To impart in depth knowledge to the students with new developments in the area of energy metabolism and its relation to human health and to learn the new concepts.

Theory

Block 1. Bio energetics

Unit I: Basics of Bio energetics

Scope and application of bioenergetics for human nutrition; energy types, energy store in man, its components and measurements.

Unit II: Estimation of Energy

Methods of estimation of energy requirement; factors affecting energy requirements and expenditure.

Unit III: Thermogenesis

Thermogenesis; interrelationship between metabolic regulation.

Block 2. Hormones in energy metabolism

UnitI. Mechanism of Hunger

Mechanism of hunger and its energy cost of macro molecules. Weight control and obesity-role of adipose tissues.

Unit II. Hormones on Energy metabolism

Effect of hormones on energy metabolism.

References

- DRISKELL, J. A. AND WOLINSKY, I., 2007, Sports Nutrition: Energy Metabolism and Exercise. 2nd Edition. CRC Press, New York.

- SCOTT, B., 2008, A Primer for the Exercise and Nutrition Sciences: Thermodynamics, Bioenergetics, Metabolism. Humana Press Inc. New York.
- KORBONITS, M., 2008, Obesity and Metabolism. Karger Publishers, London.
- DONOHOUE, P. A., 2010, Energy Metabolism and Obesity. Humana Press Inc. New York.

FSN 606 NUTRITION AND AGRICULTURE INTERFACE (2+0)

Objective

To give an understanding of inter linking agricultural production and nutritional status of the population and assist to evaluate the agriculture in terms of nutrition.

Theory

Block 1. Food and Nutrition in agriculture

Unit I: Food Situation

Food production and consumption trends; food balance sheets.

Unit II: Nutrition in Agricultural Planning

Role of nutrition in agricultural planning and national development. Linkages between agricultural practices; food production, food distribution and nutritional status; food crop failure and malnutrition; poverty and vicious cycle of low food production.

Block 2. Food availability

Unt I: Consumption Indicators

Consumption indicators, nutritional status indicators and their role in agricultural planning. Agricultural development and its effect on food availability

Unit II: Food Production

Effect of food production and economic policies on food availability; impact of physical resources, farming systems, cropping system,inputs and manipulation, agricultural marketing system, post-harvest processing of foods on food and nutrition situation.

Unit III :Food distribution systems

Food distribution systems. Food and nutrition security at national and household level; nutrition policy implementation; nutritional impact of agricultural programmes, food price control and consumer subsidy

Unit IV: Contribution of Organizations

Contribution of national and international organization for agricultural development.

References

- GOI, 2016, Agricultural Statistics at a Glance. Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation and Farmers Welfare Directorate of Economics and Statistics, Government of India.
- GOI, 2017, Agriculture - Statistical Year Book India. Ministry of Statistics and Programme Implementation, Government of India.
- GOI, 2011, Census of India. Government of India.
- GOI, 2018, A Reference Manual by Publication Division. Ministry of Information about Broadcasting, Govt. of India.
- FAO, 2017, The State of Food and Agriculture - Leveraging Food Systems for Inclusive Rural Transformation. Food and Agriculture Organization, Rome.
- FAO, 2017, The State of Food Security and Nutrition in the World. Food and Agriculture Organization, Rome.

FSN 607 NUTRITION IN EMERGENCIES (1+0)

Objective

To give theoretical base to the students in the management of food and nutritional security during emergencies and to equip them with the knowledge of providing effective support systems.

Theory

Block 1. Effects of emergency

Unit I: Starvation in Emergency

Starvation in emergencies arising out of drought, floods, earth quakes, locust, war, climate change policies and poverty; historical perspectives.

Unit II: Food shortage in emergency.

Effect of inflation, short, medium and long term emergencies on food and nutrients intake, precautions against food shortage.

Block 2: Management of emergencies

Unit I: Food needs during emergency

Food needs at national level during normal emergencies, Major nutritional deficiency diseases in emergencies; mobilization of local resources; general fund distribution; mass and supplementary feeding; therapeutic feeding; COVID19: social funds.

Unit II: Control of communicable diseases

Control of communicable diseases; public health and hygiene problems during emergencies.

References

- GIBNEY, M. J., 2004, Public Health Nutrition. Blackwell Science, Oxford.
- PARK, K., 2007, Text book of preventive and Social Medicine 19th Edition. Banarsidas Bhanot Publishers, Jabalpur, India.
- SPARK, A., 2007, Nutrition in Public Health: Principles, Policies and Practice. CRC Press, New York.
- WHO, 2000, The Management of Nutrition in Major Emergencies. World Health Organization, Geneva.
- FAO, 2018, Climate Change Challenge Badge. 2nd edition. Food and Agriculture Organization of United Nations, Rome.

FSN 608 APPLICATION OF BIOTECHNOLOGY IN FOODS AND NUTRITION (2+0)

Objective

To understand the role of food biotechnology in quality food production and to equip the students with knowledge of application of biotechnology in the process of food product development

Theory

Block 1. Biotechnology in Nutrition

Unit I: History and Application of Food Biotechnology

History, processes and products of biotechnology;

Application of biotechnology in production of nutritious foods.

Unit II: Biotechnology in product development.

Role of biotechnology in enzymology and product development, fermentation process, fruit juice extraction, genetic improvement of food grade microorganisms.

Block 2. Significance and constraints of Food Biotechnology

Unit I: Nutritional Significance of biotechnological techniques.

Nutritional significance of food products developed by biotechnological techniques.

Unit II: Constraints of Food Biotechnology

Scientific technological and resourcebconstraints on biotechnology; important factors affecting development in biotechnology.

References

- NESTLE, M., 2003, *Safe Food: Bacteria, Biotechnology and Bioterrorism*. University of California Press Ltd., London.
- SS'HETTY, K., PALIYATH, G., Pomet to A and Levin RE (2011) *Food Biotechnology*. 2nd Edition, CRC Press, NewYork.

- RAVISHANKAR RAI, V., 2015, *Advances in Food Biotechnology*. Wiley-Blackwell Publishing Company, Boston.
- PANESAR, P. S. AND MARWAHA., 2014, *Biotechnology in Agriculture and Food Processing: Opportunities and Challenges*. CRC Press, Boca Raton, Florida.

FSN 609 GLOBAL NUTRITIONAL PROBLEMS (2+0)

Objective

To make the students knowledgeable about the world scenario of prevailing malnutrition in variegated forms and measures being adopted at international / national levels.

Theory

Block 1: Global Food situation

Unit I: Food situation in India and in the world

Nutrition and health programmes to all eviate malnutrition. Role of national and international organizations light of prevalence, etiology, Indicators and preventive measures.

Unit II: Nutrition situation in developed Countries

An overview of world nutrition situation and assessment Problems of developed countries in light of Prevalence, etiology, indicators and preventive measures.

Unit III: Role of Organizations.

Nutrition & health programme to alleviate malnutrition. Role of national & international organizations.

References

- PARK, J. E. AND PARK, K., 2007, Text Book of Preventive and Social Medicine. Barnasi Das Bhanot Publishers, Jabalpur.

- SEMBA, R. D. AND BLOEM, M. W., 2008, Nutrition and Health in Developing Countries. 2nd Edition. Humana Press Inc. New York.
- TEMPLE, N. J. AND STEYN, N., 2016, Community Nutrition for Developing Countries. AU Press, Athabasca University, Canada and UNISA Press, University of South Africa.
- Babu, S. C., Gajanan, S. N. and Hallam, J. A., 2017, Nutrition Economics-Principles and Policy Applications. Science Direct. Elsevier.
- FAO, 2017, Regional Overview of Food Security and Nutrition in Asia and the Pacific. Food and Agriculture Organization, Rome.

FSN 610 MATERNAL AND CHILD NUTRITION (1+1)

Objective

To impart in-depth knowledge about vulnerable groups and their needs in terms of nutrition and other health care areas and to identify risks and coping strategies

Theory

Block 1: Importance of maternal and child nutrition

UNIT I: Scenario of Maternal and Child Nutrition.

Current scenario of maternal and child nutrition; First 1000 days of life:

Unit II: Nutrition during pregnancy

Nutritional aspect of embryogenesis; Factors affecting outcome of pregnancy;

Block 2: Pre and postnatal and nutrition during infancy

Unit I: Pre and Post natal physiological changes

Physiological changes in body composition and mental development in relation to prenatal and postnatal nutrition.

Unit II: Maternal Nutrition on Breast milk.

Effect of nutritional status of mother on quantity and quality of breast milk; recent guidelines in infant feeding and complementary feeding.

Feeding of premature babies; HIV and breast feeding; drug abuse and breast feeding

Unit III: Feeding of Babies

Block 3. Nutrition during preschool and school age

Unit I: Nutritional Problems

Nutritional problems and requirements of preschool and school going children; growth and development of children; growth monitoring using growth charts.

Unit II: Strategies to improve maternal and child nutrition

Strategies to improve maternal and child health in India: role of BPNI in promotion of breast feeding inIndia; importance of world breast feeding week.

Practical

1-6 Preparation of a database on prevailing supplementary and weaning practices - planning, collecting data, analyzing data, writing report;

7-10: Preparation of low cost complementary foods

11-15: Analysis of weaning / complementary foods for its nutrient content.

References

- MORGAN, J. B. AND DICKESON, J. W. T., 2003, Nutrition in Early Life. John Wiley and Sons Ltd. Chichester.
- EHIRI, J., 2009, Maternal and Child Health - Global Challenges, Programs and Policies. Springer Nature, Switzerland.
- BROWN, J. E., 2016, Nutrition through the Life Cycle. 6th Edition. Cengage Learning, Boston.

Ph.D. in Genetics and Plant Breeding

Course Code	Course Title	Credit Hours
GPB 601	Advances in Plant Breeding Systems	3 (3+0)
GPB 602	Advances in Biometrical Genetics	3 (2+1)
GPB 603	Molecular Cytogenetics for Crop Improvement	2 (2+0)
GPB 604	Plant Genetic Resources, Conservation and Utilization	2 (2+0)
GPB 605	Genomics in Plant Breeding	3 (3+0)
GPB 606	Population Genetics	2 (2+0)
GPB 607	Crop Evolution	3 (3+0)
GPB608	Breeding Designer Crops	2 (1+1)
GPB 609	IPR and Regulatory Mechanisms	1 (1+0)
	Total	**21 (19+2)**
GPB 680	Qualifying Examination	3 (0+3)
GPB 681	Seminar -I	1 (0+1)
GPB 682	Seminar - II	1 (0+1)
GPB 683	Teaching Assistantship -I	1 (0+1)
GPB 684	Teaching Assistantship - II	1 (0+1)
GPB 691	Research -I	18 (0+18)
GPB 692	Research -II	18 (0+18)
GPB 693	Research -III	18 (0+18)
GPB 694	Research -IV	18 (0+18)

GPB 601 ADVANCES IN PLANT BREEDING SYSTEMS 3 (3+0)

Objectives

This course is essential to understand the reproductive systems existing in crop plants that would aid in strategizing breeding methodologies

Aim of the course

To impart the theoretical knowledge on processes involved in evolution of different plant breeding systems and their significance in plant breeding.

Theory

Block I: Genetics behind formation of different whorls of a flower and its structure

Unit I: Flower Structure, Genes governing formation of different whorls and various models proposed; Advances in reproductive biology of crops;

Block II

Unit I: Genetic resources: primary, secondary, tertiary and alien trans gene pool; Wide hybridization, Pollen pistil interaction: biochemical and molecular basis, environmental factors governing an thesis and bottlenecks for gene transfer.

Plant Breeding methodologies: Classical versus modern; Over view of Pre and post Mendelian breeding methods in self and cross pollinated crops;

Unit II: Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection,; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops- Assumptions and realities.

Unit III: Doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

Block III

Unit I: Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

Block IV

Unit I: Male Sterility, types, CMS and GMS, Use of male sterility in plant breeding –case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile lines: Concepts and breeding strategies; Case studies – Generating new cyto-nuclear interaction system for diversification of male sterility; Stability of male sterile lines Molecular and biochemical basis of male sterility. Genetic engineering technology to create male sterility, prospects and problems.

Unit II: Environmental influence on male sterility. Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS;, Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use heterosis breeding; nucleocytoplasmic interactions with special

Unit III: Self-incompatibility, classification, heteromorphic and homomorphic self-incompatibility. Molecular and biochemical basis of self-incompatibility. Genetics of self-incompatibility and use of self-incompatibility in plant breeding.

Unit IV: Apomixis and its use heterosis breeding; Incongruity: Factors influencing incongruity Methods to overcome incongruity mechanisms.

References

- AGARWAL RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.
- ALLARD RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.
- BRIGGS FN AND KNOWLES PF. 1967. *Introduction to Plant Breeding*. Reinhold.
- FEHR WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.
- HAYES HK, IMMER FR AND SMITH DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.

- KANG MS AND PRIYADARSHAN PM (Edit.). 2007. *Breeding Major Food Staples.* Blackwell Publishing.
- KOLE C. 2013. *Genomics & Breeding for Climate-Resilient Crops*. Springer. Volume 2-Target Traits.
- MANDAL AK, GANGULI PK AND BANERJI SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.
- RICHARDS AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.
- SHARMA JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
- SIMMONDS NW. 1979. *Principles of Crop Improvement*. Longman.
- WELSH JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

GPB 602 ADVANCES IN BIOMETRICAL GENETICS 3 (2+1)

Objective of the course

To impart theoretical knowledge and computation methods for non-allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

Block I: Analytical tools (first and second degree statistics) to understand inheritance of quantitative traits

Unit I: Qualitative and quantitative traits and their conceptual differences; analytical tools (first-, second-, third- and fourth degree-statistics) and basic population types to model quantitative traits inheritance; relative merits and demerits of genetics of quantitative traits based on first-, second-, third- and fourth degree-statistics.

Unit II: Components of generation means-additive, dominance and epistasis gene effects, Fisher's concept of additive effect of genes using regression of genotypic value on number of alleles; breeding value, coefficient of gene dispersion; scaling and joint scaling tests to examine the adequacy of additive-dominance model; expectation of generation mean in various types of families; epistasis- definition and parameters specifying different types of epistasis; perfect-fit solutions for detect and estimation of parameters specifying epistasis.

Unit III: Component of variances - variance of different generations, estimation of parameters specifying components of variability in breeding populations; relative magnitudes of additive and dominance genetic variances; joint consideration of first degree statistics (additive and dominance genetic effects) and second degree statistics (additive and dominance genetic variances) for interpretation of quantitative traits inheritance; detection of epistasis using triple test cross analysis; concept of combining ability, its types and their estimation.

Block II: Genotype × environment interaction: its detection types and approaches to exploit in plant breeding

Unit I: G × E Interaction (GEI) - detection, quantification and approaches to exploit in plant breeding; models to detect and characterize GEI- Eberhart and Russel model, Additive Main Effect and Multiplicative Interaction (AMMI) GGE biplot models; best practices of using AMMI model; diagnosis of best AMMI model family member; concept of stability and adaptability– graphical (bi-plot) and analytical (using parameters) tools to assess stability/adaptability of genotypes across temporal and spatial environments.

Block III: Concept of markers and plant breeding by design

Unit I: Different types of markers; concept of framework linkage map development; construction of saturated linkage maps; QTL mapping in bi-parental populations-approaches (single marker, interval marker and multi-marker) and analytical tools (regression and maximum likelihood methods); QTLs mapping in natural (germplasm) and genetically diverse breeding populations such as NAM and MAGIC populations; Marker Assisted Selection (MAS) and approaches for its application in plant breeding – marker-assisted backcrossing, F_2 enrichment, marker-assisted recurrent selection (MARS);; factors influencing MAS; trait heritability, and linkage disequilibrium between markers and traits; use of advanced software packages for linkage map construction, QTL mapping in bi-parental populations and natural populations and interpretation of analyzed data; QTL mapping-free MAS (genomic selection) – factors affecting genomic selection.

Practical

Generation mean analysis; Fisher's concept of average effect of allelic substitution; regression of genotypic values on number of alleles; triple test cross analysis; stability analysis; AMMI model diagnosis-postdictive and predictive accuracy and estimation of AMMI stability parameters; concepts of root mean square prediction difference (RMSPD) for AMMI model diagnosis; Approaches (Single marker, two markers and multiple markers) and analytical tools (ANOVA, 't' test, 'F' test and Regression) for QTL mapping in bi-parental mapping populations. QTL mapping in natural populations (association mapping) using regression.

References

- MATHER K AND JINKS JL. 1982. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.
- WRICKE G AND WEBER WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.
- SINGH RK AND CHOUDHARY BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani Publishers, New Delhi.
- WEIR DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Dat*a. Sinauer Associates.
- DABHOLKAR AR.1993. *Elements of Biometrical Genetics*. Concept Publishing Co. New Delhi.
- BOS I AND CALIGARI P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
- FALCONER DS AND MACKAY J. 1996. *Introduction to Quantitative Genetics* (4 Ed.). ELBS/ Longman, London.
- ROY D. 2000. *Plant Breeding*, *Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.
- REX BERNARDO. 2020. *Breeding for Quantitative Traits in Plants*. Third edition, Stemma Press, Woodbury, Minnesota, USA

- GEORGE ACCQUAAH. 2020. *Principles of Plant Genetics and Breeding*. Third Edition, Wiley-Blackwell, USA.

GPB 603 MOLECULAR CYTOGENETICS FOR CROP IMPROVEMENT 2(2+0)

Objectives

Molecular cytogenetics is aimed at studying molecular methods of the structure and function of the cellular constituents concerned in heredity, including molecular analysis of chromosomes using various molecular techniques to visualize one or more specific regions or whole of the genome. Use fluorescence in situ hybridization technique enhances interpretation of numerical and complex chromosome aberrations, bridging the gap between conventional chromosome banding analysis and molecular genetic DNA studies. Molecular cytogenetics allow a more efficient and rapid assessment of chromosomal imbalance in all or most of the cells.

Aim of this course

This course is aimed at giving theoretical knowledge on genome analysis, FISH, GISH, chromosome mapping techniques, trisomics, Cytogenomics, Polyploidy and their applications in crop improvement

Theory

BLOCK 1

Unit I : Genome Analysis: Organization and structure of genome, Genome size, Organization of organellar genomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions; Variation in DNA content - C value paradox, Sequence complexity – Introns and Exons.

Unit II : **Techniques for karyotyping:** Chromosome banding and painting-*In situ* hybridization: FISH and GISH and their application in plant Breeding.

BLOCK 2

Unit I: Pre-breeding and applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes:

deficiency method; Interchange genetic consequence; balanced lethal systems, their maintenance and utility; Duplication - production and use; Inversions and location of genes; B/ A chromosome translocations and gene location.

Unit II: Trisomics- types, production, breeding behavior, use of balanced tertiary trisomics in hybrid seed production; Monosomics: methods of production, breeding behavior and location of genes; Intervarietal substitutions; Telocentric method of mapping.

BLOCK 3

Unit I: Cytogenomics: Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location.

BLOCK 4

Unit I: Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distant hybridization, barriers to interspecific and intergeneric hybridization; Behaviour of interspecific and intergeneric crosses. Alien addition and substitution lines, Alien translocation lines: Their production and uses in gene transfer with examples.

References

- CLARK, M.S. AND WALL, W.J., 1996, Chromosomes: The Complex Code. Chapman & Hall.
- CONGER, B.V., 1981, Cloning Agricultural Plants via in-vitro Techniques. CRC Press.
- CONSTABEL, F AND VASIL, I.K., 1988, Cell Culture and Somatic Cell Genetics of Plants. Vol.V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.
- GUPTA, P. K., 2006, Cytogenetics. Rastogi Publisher
- LAL, R. AND LAL, S., 1990, Crop Improvement Utilizing Biotechnology. CRC Press.
- MANTEL, S.H. AND SMITH, H., 1983, Plant Biotechnology. Cambridge University Press.
- SEN, S. K. AND GILES, K.L.,1983, Plant Cell Culture in Crop Improvement. Plenum Press.

- YAO-SHAN, F., 2002, Molecular Cytogenetics: Protocols and Application. Human Press.

GPB 604 PLANT GENETIC RESOURCES, CONSERVATION AND UTILIZATION 2(2+0)

Theory

Block 1: Conservation of Plant Genetic Resources

Unit I: Concept of natural reserves and natural gene banks; *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

Unit II: *Ex situ* conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and exchange to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling, clonal repositories, genetic stability under long term storage condition.

In-vitro storage, maintenance of *in-vitro* culture under different conditions, *in-vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in-vitro* gene bank.

BLOCK 2 : Cryopreservation

Unit I: Cryopreservation- procedure for handling seeds of orthodox and recalcitrant-cryo- protectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/ dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

Block 3 : Plant Genetic Resources Management

Unit 1: Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and mini core; collections and registration of plant germplasm.

References

- ELLIS RH, ROBERTS EH AND WHITE HEAD J. 1980. *A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks*. FAO/ IBPGR Pl.
- GENET. Resources News 41-3-18.
- FRANKEL OH AND HAWKES JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, Cambridge.
- PARODA RS AND ARORA RK.1991. *Plant Genetic resource Conservation and management*, NBPGR, New-Delhi.
- SIMMONDS NW. 1979. *Principles of Crop Improvement,* Longman.
- WESTWOOD MN. 1986. *Operation Manual for National Clonal Germplasm Repository.* Processed Report. USDA-ARS and Oregon State Univ. Oregon, USA.
- WITHERS LA. 1980. *Tissue Culture Storage for Genetic Conservation*. IBPGR Tech. Rep. IBPGR, Rome, Italy.

GPB 605 GENOMICS IN PLANT BREEDING 3(3+0)

Objective of the Course

To impart practical skills in advanced molecular techniques in genome mapping structural/ functional genomics.

Theory

Block 1: Genome Architecture

Unit I: Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity:

Block 2: Genome sequencing and its application in plant breeding

Unit I: Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

Block 3: Genomics and its utility in plant breeding

Unit I: Molecular maps: large-scale SSR/SNP genotyping techniques, Diversity array technology: concepts and applications. Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/ QTL mapping, genome wide association studies (GWAS), XP-GWAS and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Genomic selection (GS)

Unit II: Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: massively parallel signature sequencing, next generation sequencing, , RT-PCR, qRT-PCR, digital PCR and molecular beacon.

Block 4: Basics of Bioinformatics

Unit I: Development and management of database; Applications of bioinformatics tools/ software in genomics for crop improvement. Basic concepts of high-throughput proteomics, and phenomics.

Block 5: Breeding by design/Precision plant breeding

Unit I: Use of transgene-free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Concept of SDN1, SDN2 and SDN3 and regulatory mechanism associated with gene edited crop varieties.

References

- ALONSO JM, STEPANOVA AN. 2015. Plant Functional Genomics: Methods and Protocols. Springer.
- CHOPRA VL, SHARMA RP, BHAT SR AND PRASANNA BM. 2007. Search for New Genes. Academic Foundation, New Delhi.
- HACKETT PB, FUCHS JA AND MESSING JW. 1988. An Introduction to Recombinant DNA Technology - Basic Experiments in Gene and Manipulation. 2nd Ed. Benjamin Publication Co.
- PRIMOSE SB AND TWYMAN RM. 2006. Principles of Gene Manipulation and Genomics. 7th Ed. Wiley-Blackwell Publishing.
- SAMBROOK J AND RUSSEL D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Laboratory Press.
- SINGH BD. 2005. Biotechnology: Expanding Horizons. Kalyani Publishers, New Delhi.
- SOMERS DJ, LANGRIDGE P, GUSTAFSON JP. 2009. Plant Genomics: Methods and Protocols. Springer.

e-Resources

http://gramene.org

https://www.arabidopsis.org

https://wheat.pw.usda.gov

http://ncbi.nlm.nih.gov

http://www.maizegenetics.net

GPB 606 POPULATION GENETICS 2 (2+0)

Objective of the course

To impart knowledge on structure, properties and their breeding values of different populations.

Theory

Block I: Dynamics of genes, genotypes and their frequencies in natural populations

Unit I: Concepts of gene and genotype frequency and genetic constitution in natural random mating populations; frequency of genes and genotypes as a function of population size, differences in fertility and viability, migration and mutation.

Unit II: Hardy-Weinberg (HW) equilibrium; test of HW equilibrium; mating frequencies: non-dominance, co-dominance, Snyder's ratio, importance and its effect over random mating in succeeding generations.

Unit III

Population genetics of multiple alleles and loci, sex linked genes; dynamics of gene frequency as a function of migration, mutation, recurrent and non-recurrent selection; balance between selection and mutation; selection favoring heterozygotes; over-dominance for fitness; homoeostasis- adaptive organization of gene pools co-adapted gene complexes; polymorphism - balanced and non-balanced polymorphism, heterozygous advantage - survival of recessive and deleterious alleles in populations.

Block II: Dynamics of genes, genotypes and their frequencies in plant breeding populations

Unit I: Modes of reproduction and desired crop cultivar genetic constitution; H-W equilibrium and its importance in crop cultivar performance and stability; nonrandom mating-selfing, sibmating, assortative mating and dis-assortative mating; consequences of restricted random mating as an effect of inbreeding and inbreeding in pedigreed populations; effect of sib mating in crops; correlation between relatives and estimation of inbreeding coefficient (F); types of responses to selection; comparative consequences of selfing and backcrossing and their implications in selection response; genetic drift.

References

- LI CC. 1955. *Population Genetics*. The Univ. of Chicago Press.
- MATHER K AND JINKS JL. 1982. *Biometrical Genetics*. Chapman & Hall. London

- JAIN JP AND PARBHAKARAN VT. 1992. *Genetics of Populations*. South Asia Books.
- TOMAR SS. 1992. *Text Book of Population Genetics*. Universal Publication.
- FALCONER DS AND MACKAY J. 1996. *Introduction to Quantitative Genetics*. Longman.
- SORRENS D AND DONIEL G. 2007. *Methods in Quantitative Genetics*. Series: *Statistics for Biology and Health*, Likelihood.
- REX BERNARDO. 2020. *Breeding for Quantitative Traits in Plants*. Third edition, Stemma Press, Woodbury, Minnesota, USA
- GEORGE ACCQUAAH. 2020. *Principles of Plant Genetics and Breeding*. Third Edition, Wiley-Blackwell.

GPB 607 CROP EVOLUTION 3(3+0)

Theory

Block 1 : Origin & Early Domestication

Unit I: Origin and evolution of species; Centres of diversity/ origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies; Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift – Consequences.

Unit II: Speciation and domestication–The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization - speciation and extinction; Exploitation of natural variation: Early attempts to increase variation, Distant hybridization and introgression, Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.

Block 2 : Cytogenetic Evolution of Crop Plants

Unit I: Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization –

Transgenesis in crop evolution, Multifactorial genome, Intragenomic interaction, Intergenomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.

Unit II: Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of autopolyploids; haploidy and DH-method of production and use, allopolyploids; synthesis of new crops; Case studies – Cereals, Pulses, Oilseeds, vegetables, Fibre crops, Plantation crops, Forage crops, Tuber crops, Medicinal Plants.

References

- HANCOCK JF. 2004. *Plant Evolution and the Origin of Crop Species*. 2nd Ed. CABI.
- LADIZINSKY G. 1999. *Evolution and Domestication*. Springer.
- MILLER AJ. 2007. *Crop Plants: Evolution*. John Wiley & Sons.
- SMARTT J AND SIMMONDS NW. 1995. *Evolution of Crop Plants*. Blackwell.

GPB 608 BREEDING DESIGNER CROPS 2(1+1)

Block 1 : Fundamentals of Designing Crops

Unit I: Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.

Unit II: Breeding for special traits, viz., oil, protein, vitamins, amino acids, etc.; Ecospecific ideotypes, Ideotypes for high and low moisture conditions, low and high input conditions, Determination of genetics of above mentioned traits.

Unit III: Plant-water relationships, enhancing input use efficiency through genetic manipulations.

Block 2 : Targeted Production

Unit I: Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming.

Block 3 : Biosafety issues in Designer Crops

Unit I: Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

Practical

- Demonstration of plant responses to stresses through recent techniques;
- Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/ drought/ salt shock proteins.

References

- BALINT A. 1984. *Physiological Genetics of Agricultural Crops*. AK Ademiaikiado.
- HAY RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
- PESSARAKLI M. 1995. *Handbook of Plant and Crop Physiology*. Marcel Dekker.
- TAIZ L AND ZEIGER E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.s

GPB 609 IPR AND REGULATORY MECHANISM 1(1+0) (e-course)*

Theory

Block 1 : Structure of Intellectual Property Protection

Unit 1: Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection;

Block 2 : Biodiversity protection

Unit 1: National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Block 3 : Biosafety Issues

Unit 1: Biosafety and risk assessment issues; cross border movement of GMO/LMO material; National biosafety policies; Cartagena Protocol on biosafety, Nagoya Protocol, GEAC.

Ph.D. in Horticulture

Course Code	Course Title	Credit Hours
HRT 601	Advances in Production Technology of Fruits	3 (2+1)
HRT 602	Advances in Production Technology of Vegetable crops	3 (2+1)
HRT 603	Advances in Production Technology of Commercial flowers	3 (2+1)
HRT 604	Advances in Production Technology of Plantation, Spices, Medicinal and Aromatic Crops	3 (2+1)
HRT 605	Advances in Post-Harvest Technology of Horticulture Crops	3 (2+1)
HRT 606	Advances in Breeding of Fruit Crops	2 (1+1)
HRT 607	Advances in Breeding of Vegetable Crops	2 (1+1)
HRT 608	Advances in Plant Propagation of Fruit Crops	2 (1+1)
HRT 609	Advances in Nutrient Management of Fruit Crops	2 (1+1)
HRT 610	Advances in Landscape Gardening	2 (1+1)
HRT 611	Biotechnology of Fruit and Plantation Crops	2 (1+1)
HRT 612	Biotechnology of Vegetable and Flower Crops	2 (1+1)
	Total	**29 (17+12)**
HRT 680	Qualifying Examination	3 (0+3)
HRT 681	Seminar - I	1 (0+1)
HRT 682	Seminar - II	1 (0+1)
HRT 683	Teaching Assistantship - I	1 (0+1)
HRT 684	Teaching Assistantship - II	1 (0+1)
HRT 691	Research - I	18 (0+18)
HRT 692	Research - II	18 (0+18)
HRT 693	Research - III	18 (0+18)
HRT 694	Research - IV	18 (0+18)

HRT 601 ADVANCES IN PRODUCTION TECHNOLOGY OF FRUITS (2+1)

Objective

To impart comprehensive knowledge about the advance production technology of major tropical and sub tropical fruit crops.

Theory

Block 1: Importance, scope, scenario, soil and climate for fruit production

Unit I: National and International scenario in fruit production area and production of fruits, current scenario of fruit production and export in India and world.

Unit II: Horticulture development scenario in the State - current fruit production scenario in Karnataka and India. Fruit zones of India.

Unit III: Importance - economical, nutritional, medicinal, value added products and others like kitchen garden. Scope – adoptability, export value, future prospective

Unit IV: Soil – major components of soil, its importance, physical and chemical conditions, soil pH and nutrient status of the soil. Climate – temperature, humidity, wind, rainfall, hailstorms and solar radiation.

Block 2: Modern methods of propagation techniques and rapid multiplication of fruit plants.

Unit I: Plant propagation definition and methods of propagation. Seed propagation – advantages and disadvantages.

Unit II: Vegetative propagation - advantages and disadvantages, different methods *viz.,* Cuttings: stem cutting, leaf cutting, root cutting. Grafting: advantages and disadvantages, scion, stock and interstock relationship, methods – approach / inarch, veneer, epicotyl/stone, soft wood grafting. Budding- shield / T –budding, patch, chip, ring, flute budding. Layering- ground, mound, air layering. Specialized structures- rhizomes, suckers, runners, crowns, slips, stolons.

Unit III : Micro-propagation – Plant Tissue Culture definition, advantage, disadvantage, limitation and steps in micro propagation.

Block 3 : Crop modeling, water management and use of growth regulators in fruit production.

Unit I: Cropping system, monocrops, intercrops, mixed crops etc., High density orcharding/ planting techniques.

Unit II: Irrigation management methods surface, sub-surface, sprinkler and drip irrigation. Fertigation drip fertigation advantages and disadvantages, methods of nutrient application and management in fruit crops. Weeds classification, detrimental effects of weeds on crops and non-crop situations, methods of weed control – chemical and non – chemical methods.

Unit III: Definition, type of growth regulators substances, use of growth regulators in propagation rooting of cuttings, induction of rooting in layers, union of root stock and scion in grafting and budding, control of flowering, fruit set, fruit drop, parthinocarpy, fruit ripening, fruit size, quality and sex expression.

Block 4: Advance production technology of tropical and sub tropical fruits

Unit I: Detailed horticultural practices followed for cultivations, varieties - hybrids, propagation techniques. Major pests and diseases, physiological disorders and other important techniques like total quality management for **Mango, Banana, Citrus Spp., Grapes, Sapota, Guava, Papaya, Pineapple, Pomegranate, Jackfruit, Fig, Avocado And Aonla / Nelli.**

Block 5: Advance production technology of temperate fruits

Unit I: Detailed horticultural practices followed for cultivations, varieties - hybrids, propagation techniques. Major pests and diseases, physiological disorders and other important techniques like total quality management of **Apple, Peach, Pear, Plum, Cherry, Apricot, Strawberry and Nut crops (Walnut etc.,).**

Practicals

- Nursery and propagation structures
- Modern methods of propagation
- Fruit tree canopy management
- Recent techniques in fruit breeding
- Integrated nutrient management practices
- Application of growth regulators
- Water management and plant protection practices
- Dry land fruit orchard management practices
- Organic production of fruit crops
- Visit to commercial nurseries and research institutes

Reference

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- HARTMANN, H. T. AND KESTER, D. E., 1986, *Plant Propagation-Principles and Practices*, 4th Edition, Prentice-Hall, Inc., N. J., USA PP 727.

HRT 602 ADVANCES IN PRODUCTION TECHNOLOGY OF VEGETABLE CROPS (2+1)

Objective

To impart comprehensive knowledge about the advance production technology of vegetable crops

Theory

Block 1: Production technology of tomato, potato, eggplant, hot and sweet peppers

Unit I: Present scenario and prospects of these vegetables in India and world.

Unit II: Factors limiting vegetable production

Unit III: Nursery management, plant geometry and density, choice of varieties and hybrids, multiple cropping systems, crop growth regulation, mineral nutrition and fertigation, integrated nutrient management; herbicide application, mulching, irrigation management

Unit IV: Mechanization, plant protection, IPM in vegetables, harvesting, curing, drying, seed production technique

Unit V: Protected cultivation of tomato and Sweet pepper

Block 2: Production technology of cucurbits like cucumber, muskmelon, watermelon, gourds and pumpkin

Unit I: Present scenario and prospects of these vegetables in India and world

Unit II: Nursery management, plant geometry and density, choice of varieties and hybrids, multiple cropping systems, crop growth regulation, mineral nutrition and fertigation, integrated nutrient management; herbicide application, mulching, irrigation management,

Unit III: Mechanization, plant protection, IPM in vegetables, harvesting, curing, drying, seed production technique

Unit IV: Protected cultivation of European cucumber

Block 3: Production technology of cabbage, cauliflower, knol-khol, broccoli, brussels sprouts

Unit I: Present scenario and prospects of vegetables in India and world

Unit II: Nursery management, plant geometry and density, choice of varieties and hybrids, multiple cropping systems, crop growth regulation, mineral nutrition and fertigation, integrated nutrient management; herbicide application, mulching, irrigation management.

Unit III: Mechanization, plant protection, IPM in vegetables, harvesting, curing, drying, seed production technique.

Block 4: Production technology of bhendi, onion, peas, beans, amaranthus and drumstick

Unit I: Present scenario and prospects of these vegetables in India and world

Unit II: Nursery management, plant geometry and density, choice of varieties and hybrids, multiple cropping systems, crop growth regulation, mineral nutrition and fertigation, integrated nutrient management; herbicide application, mulching, irrigation management

Unit III: Mechanization, plant protection, IPM in vegetables, harvesting, curing, drying, seed production technique

Unit IV: Hydroponics, Nutrients Film Technique (NFT)

Unit V: Special techniques in vegetable farming

Block 5: Production technology of carrot, beet root, radish, sweet potato, tapioca, elephant foot yam and taro

Unit I: Present scenario and prospects of these vegetables in India and world.

Unit II: Nursery management, plant geometry and density, choice of varieties and hybrids, multiple cropping systems, crop growth regulation, mineral nutrition and fertigation, integrated nutrient management; herbicide application, mulching, irrigation management

Unit III: Mechanization, plant protection, IPM in vegetables, harvesting, curing, drying, seed production technique

Practicals

- Diagnosis of nutritional and physiological disorders

- Assessing nutrient status of plants
- Application of plant growth substances
- Practices in herbicides application
- Estimating water requirements in relation to crop growth stages
- Fertigation
- Maturity indices and quality analysis
- Visit to commercial nurseries and research institutes

Reference

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- CHOUDHURY, B., Vegetables
- HAZRA, P. AND SOM, M., Technology for Vegetable Production and improvement
- SINGH, R. S., Diseases of vegetable Crops
- THAMBURAJ, S. AND SINGH, N., Text book of vegetable, tuber crops and spices
- THOMPSON, H. C. AND KELLY, W. C. Vegetable Crops
- GOPALKRISHNAN. T. R., Vegetable crops

HRT 603 ADVANCES IN PRODUCTION TECHNOLOGY OF COMMERCIAL FLOWERS (2+1)

Objective

To impart comprehensive knowledge about the advance production technology of commercial flower crops.

Theory

Block 1: Importance and Global Scenario of commercial flower crops

Unit I: Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Special practices in cut and loose flowers. Export potential, Agri Export Zones.

Unit II: Importance of dry flowers, selection of planting material and different methods of drying techniques.

Unit III: IPR issues and plant quarantine

Unit IV: Greenhouse management

Block 2: Production technology of Rose and Chrysanthemum

Unit I: Soil/media sterilization techniques; Micro-irrigation; nutrition and fertigation; slow release fertilizers and bio-fertilizers.

Unit II: Environmental manipulation, Influence of environmental factors-light, temperature, moisture, humidity and CO_2 on growth and flowering; growth regulation for quality flowers. Flower forcing and year-round flower production through physiological interventions; Chemical regulation.

Unit III: Harvest indices; Harvesting techniques; Post-harvest handling; Pre-cooling, pulsing, packing, marketing.

Block 3: Production technology of Anthurium, Orchids, Carnation and Gerbera

Unit I: Soil/media sterilization techniques; Micro-irrigation; nutrition and fertigation; slow release fertilizers and bio-fertilizers.

Unit II: Environmental manipulation, Influence of environmental factors-light, temperature, moisture, humidity and CO_2 on growth and flowering; growth regulation for quality flowers. Flower forcing and year-round flower production through physiological interventions; Chemical regulation.

Unit III: Harvest indices; Harvesting techniques; Post-harvest handling; Pre-cooling, pulsing, packing, marketing.

Block 4: Production technology of Galdiolus, Tuberose, Lilliums,

Unit I: Soil/media sterilization techniques; Micro-irrigation; nutrition and fertigation; slow release fertilizers and bio-fertilizers.

Unit II: Environmental manipulation, Influence of environmental factors-light, temperature, moisture, humidity and CO_2 on growth and flowering; growth regulation for quality flowers. Flower forcing and year-round flower production through physiological interventions; Chemical regulation.

Unit III: Harvest indices; Harvesting techniques; Post-harvest handling; Pre-cooling, pulsing, packing, marketing.

Block 5: Production technology of China aster, Marigold, Jasmine, Crossandra, Bird of Paradise and Heliconia

Unit I: Soil/media sterilization techniques; Micro-irrigation; nutrition and fertigation; slow release fertilizers and bio-fertilizers.

Unit II: Environmental manipulation, Influence of environmental factors-light, temperature, moisture, humidity and CO_2 on growth and flowering; growth regulation for quality flowers. Flower forcing and year-round flower production through physiological interventions; Chemical regulation.

Unit III: Harvest indices; Harvesting techniques; Post-harvest handling; Pre-cooling, pulsing, packing, marketing.

Practicals

- Varietal wealth in flower crops
- Greenhouse management,
- Special practices- Pinching, netting, disbudding, defoliation and chemical pinching
- Photoperiodic and chemical induction of flowering.
- Assessing harvest indices, Post-harvest handling, Preparation of floral decorative
- Visit to commercial nurseries and research institutes.

References

- S. K. BHATACHARJEE & L. C. DE, Advanced Commercial Floriculture
- S. PRASAD/ U. KUMAR Commercial Floriculture
- Prof. M. M. SYAMAL Commercial Floriculture
- T. K. BOSE, L. P. YADAV, P. PAL, P. DAS. AND V. A.

PARTHASARATHY Commercial Flowers Vol.1& Vol.2

- GOPALASWAMI IYENGAR Complete Gardening in India
- J. PRAKASH AND K. R. BHANDALY Floriculture, Technology, Trades and Trends
- T. K. BOSE, R. G. MAITI, R. S. DHUA AND P. DAS, Floriculture and Landscaping
- DESH RAJ Floriculture - At Glance
- Dr. G. S. RANDHAWA AND A. MUKHOPADHYAY Floriculture in India
- S. SARASWATHI, T. L. PRRETHI, BALASUBRAMANYAM, J. SURESH, N. REVATHY, S. NATARAJAn, Post harvest Technology of Horticultural Crops
- Dr. T. VENKATESH REDDY & Dr. C. G. NAGARAJA Protected cultivation of Roses
- AMITABHA MUCHOPADHYAY Roses
- B. P. PAL The Rose in India

HRT 604 ADVANCES IN PRODUCTION TECHNOLOGY OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (2+1)

Objective

To impart comprehensive knowledge about the advance production technology of plantation, spices, medicinal and aromatic crops.

Theory

Block 1: Advance production technology of plantation crops

Unit I: Scope, prospects and advances in the propagation, crop improvement, water management, fertigation, use of growth regulators on crops like coffee, tea, cocoa, rubber, cashew nut, coconut, areca nut and oil palm.

Unit II: Designing multi-tier cropping system for high productivity in coconut and arecanut gardens.

Unit III: Integrated nutrient management and integrated management of pests and diseases.

Block 2 : Advance production technology of spice crops

Unit I: Scope, prospects and advances in the propagation, crop improvement, water management, fertigation, use of growth regulators on crops like black pepper, small cardamom, ginger, turmeric, tree, seed spices.

Unit II: Integrated nutrient management and integrated management of pests and diseases.

Block 3: Advance production technology of medicinal crops

Unit I: Scope, prospects and advances in the propagation, crop improvement, water management, fertigation, use of growth regulators on crops like coleus, amla, ashwagandha, isabgol, senna, periwinkle and *Aloe vera*.

Block 4 : Advance production technology of aromatic crops

Unit I: Scope, prospects and advances in the propagation, crop improvement, water management, fertigation, use of growth regulators on crops like aromatic grasses, mints, geranium and patchouli.

Practicals

- Detailed studies on high density planting systems, application of growth regulators, recent advances in propagation, extraction methods, pest and disease management in plantation crops.
- Detailed studies on high density planting systems, application of growth regulators, recent advances in propagation, extraction methods, pest and disease management in spice crops.
- Application of growth regulators, recent advances in propagation, extraction methods, pest and disease management in medicinal crops.
- Application of growth regulators, recent advances in propagation, extraction methods, pest and disease management in aromatic crops
- Visit to research institutes and processing units.

References

- TROPICAL HORTICULTURE, 1999, Vol. 1, Ed.: T. K. Bose, S. K. Mitra, A. A. Farooqi & M. K. Sadhu, Publishers: NayaProkash, Kolkata
- PLANTATION CROPS, Vol. 1 & Vol. 2 (2006), Ed.: V. A. Parthasarathy, P. K. Chattopadhyay & T. K. Bose, Publishers: NayaUdyog, Kolkata
- HAND BOOK OF HORTICULTURE, 2003, Ed.: K. L. Chadha, Published by ICAR
- CULTIVATION OF MEDICINAL AND AROMATIC CROPS, 2006, Ed.: A. A. Farooqi& B. S. Sreeramu Publishers: Universities Press, Hyderabad
- CULTIVATION OF SPICE CROPS, 2005, Ed.: A. A. Farooqi, B. S. Sreeramu& K. N. Srinivasappa, Publishers: Universities Press, Hyderabad.

HRT 605 ADVANCES IN POST-HARVEST TECHNOLOGY IN HORTICULTURE CROPS (2+1)

Objective

To impart comprehensive knowledge about the advances in post harvest technology of horticulture crops.

Theory

Block 1: Advances in post-harvest technology in horticulture crops

Unit I: Importance of post-harvest processing of horticulture Crops, reduction in post harvest losses, value addition, contribution to the economy, increased availability, export earnings, employment generation, adding taste and variety to foods, providing nutritional security, waste utilization, home scale preservation, reduction in cost of production, reduction in economic losses, supply for defence and astronaut's requirements, infant and speciality foods

Unit II: Extent and possible causes of post-harvest losses, possible causes of post-harvest losses: Unfavourable climate, poor cultural practices, improper storage conditions, inadequate handling during transportation, inadequate facilities available for processing, government policies, education and resources, transportation facilities

Block 2: Pre-harvest factors affecting post harvest quality

Unit I: Market factors, cultivar and rootstock genotype, environment: Light, temperature, rainfall, humidity, wind, production practices: Water supply (irrigation), soil fertility and use of fertilizers (mineral nutrition, foliar nutrient sprays), cultivation practices (weed control, crop hygiene), agricultural chemicals (pesticides and herbicides, growth regulating chemicals), canopy manipulations (crop load, fruit canopy position, leaf removal, girdling), seasons, planting density, maturity, stage of harvesting, method of harvesting, consumer demand, crop rotation.

Unit II: Maturity**,** definition of maturity, types of maturity: Physiological maturity, horticultural/ commercial maturity, judging the maturity: Culinary maturity, dessert maturity, shipping maturity, processing maturity, determination of harvest maturity indices, computational methods: Calendar date, DFFB (days from full bloom to harvest), mean heat units / degree days, T- stage, physical methods: Fruit retention strength, acoustic / sound tests, fruit size and surface morphology, shape, weight, specific gravity, colour (skin, flesh and seed), firmness / solidity, ease of separation, brittleness of the floral part, juice content, bulk density, formation of abscission layer, aroma / organoleptic quality, vibration tests, electrical characteristics, electromagnetic methods, optical methods, radiation, chemical methods: Titrable acidity, TSS/acid ratio, sugars, sugar / acid ratio, bioelectrical conductance, starch content (iodine test), tannin content, oil content, dry matter percentage, juice content, physiological methods: Rate of respiration, rate of ethylene production, transpiration, production of volatiles, geometrical methods

Block 3: Ripening and changes occurring during ripening

Unit I: Definition of ripening, changes that occur during the ripening of fruits, physical changes: Colour changes, abscission (detachment from parent part), softening, development of wax on the skin, chemical changes: Cell wall changes, changes in starch/ carbohydrate composition, organic acid changes, amino acids and protein changes, production of flavour volatiles and aroma, ascorbic acid, phenolic compounds, physiological changes: Changes in respiration rate, changes in the rate of ethylene evolution, seed maturation

Unit II: Respiration and factors affecting respiration rate, definition of respiration, factors affecting respiration rate: Stage of development, moisture content, sugar of fruit, coating on surface of fruits, type of tissue, external factors (temperature, ethylene, availability of O_2, CO_2, growth regulator application, fruit injury), biosynthesis of ethylene and its effect on issue on metabolism.

Block 4: Packaging of fruits and vegetables

Unit I: Package design, package type monitoring of packing material, MA packing.

Unit II: Storage design and methods – ZECC: Principle and operation, Cold/ Refrigerated storage, refrigerated storage: Concept, principle of refrigeration, Chilling: Concept, chilling injury, Freezing: Concept, freezing injury, jacketed storages, solar driven cold stores.

Unit III: Controlled Atmosphere Storage (CA Storage), Physiological basis, essential features, benefits and harmful Effects, Modified Atmosphere storage (MA storage), biochemical and physiological basis of MA storage, methods of creating modified atmosphere conditions (commodity generated or passive MA and active MA), Low Pressure Storage / Hypobaric Storage, concept and mechanism

BLOCK 5: Post-harvest treatment of horticulture crops

Unit I: Pre-cooling, growth regulators, skin coating, vapour heat treatment and irradiation.

Unit II: Post harvest physiological disorders and diseases of fresh fruits and vegetables and cut flowers.

Practicals

- ➢ Study of harvesting grading
- ➢ Sorting, packing, storage, transportation and marketing system. Judging and maturity indices of horticultural crops.
- ➢ Classification of packing materials and different transportation systems, shipment, road ways, railways and air cargo.
- ➢ Study of different storage structures
- ➢ Group discussion on national and International laws for import and export of fresh products.

References

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- Swati Barche and Kamal Singh Kirad, 2014, Post Harvesting Handling of Fruits, Vegetables and Flowers, Jain Brothers, New Delhi
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- GULERIA, S. P. S. AND ANIL KUMAR VERMA, 2010, Question Bank on Post Harvest Technology, New India Publishing Agency, New Delhi.

HRT 606 ADVANCES IN BREEDING OF FRUIT CROPS (1+1)

Objective

To impart comprehensive knowledge about the advances in breeding of fruit crops.

Theory

Block 1: Introduction and significance of breeding of fruit crops

Unit I: General introduction and significance; methods and advancement in breeding with special reference to mango, banana, *Citrus* sps., grape, apple, pear, stone fruits, temperate nuts, arid zone fruits.

Unit II: Overcoming breeding problems-long juvenile phase, hybrid sterility, gametophytic incompatibility;

Unit III: Genetic and phylogenetic relationship, inheritance of economically important traits; rootstock breeding : breeding for resistance to biotic and abiotic stresses.

Unit IV: Transgenic fruit plants, future thrusts. Use of markers in fruit crops breeding.

Practicals

- Determination of cross –compatibility /incompatibility using *in vivo* pollen tube growth studies
- Embryo rescue culture technique.
- Cytological and isozymic studies in cultivars identification.

References

- DHILLON, B. S., R. K. TYAGI., S. SAXENA. AND G. J. RANDHAWA., 2005, Plant Genetic Resources: Horticultural Crops. Narosa Publ. House., New Delhi.
- GUPTA, S. K., 2000, Plant Breeding. Theory and Techniques. Vedam Publishers, Solan.Harihar. Ram. 2001. Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.
- KUMAR, U. AND M. J. ASIJA., 2004, Biodiversity: Principles and Conservation Agrobios, Jodhpur.
- D. ROY., Breeding of fruit crops,
- B. NAIK. AND R. K. TARAI., Breeding of fruits and plantation crops
- R. K. RAMACHANDRA,V. NACHEGOWDA AND M. K. HONNABYRAIAH, Breeding of fruit crops.

HRT 607 **ADVANCES IN BREEDING OF VEGETABLE CROPS** **(1+1)**

Objective

To impart comprehensive knowledge about the advances in breeding of vegetable crops.

Theory

Block 1: Principles and methods of vegetable breeding

Unit I: Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination,

Unit II: Hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, in vitro breeding;

Unit III: Breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance.

Block 2: Breeding of vegetable crops

Unit I: Tomato, Brinjal, Chilli, Sweet Pepper and Potato

Unit II: Cucumber, muskmelon, watermelon, gourds and pumpkin

Unit III: Cabbage, cauliflower, knol-khol

Unit IV: Carrot, beet root, radish, sweet potato, tapioca, elephant foot yam and taro.

Practicals

- Designing of breeding experiments,
- Screening techniques for abiotic stresses,
- Screening and rating for pest, disease and nematode resistance,
- Estimation of quality and processing characters,
- Screening for-quality improvement,

- Estimation of heterosis and combining ability,
- Induction and identification of mutants and polyploids,
- Distant hybridization and embryo rescue techniques

References

- DHILLON, B. S., R. K. TYAGI., S. SAXENA. & G. J. RANDHAWA., 2005, Plant Genetic Resources: Horticultural Crops. Narosa Publ. House., New Delhi.
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HRT 608: ADVANCES IN PLANT PROPAGATION OF FRUIT CROPS (1+1)

Objective

To impart comprehensive knowledge about the advanced methods of propagation of fruit crops.

Theory

Block 1: Advanced methods of propagation of fruit crops

Unit I: Advanced methods of propagation.

Unit II: Internal and external factors influencing seed germination

Unit III: Physiological, anatomical and biochemical basis of root induction.

Unit IV: Callusing and formation of bud/graft union; stock-scion relationship

Unit V: Physiology of dwarfing rootstocks.

Unit VI: Mist propagation

Block 2: *In vitro* / Micro propagation techniques

Unit I: High volume production system, mass micro propagation, hardening technique and use of phytopackaging and transportation of micropropagules.

Unit II: Certification of planting materials through molecular markers.

Practicals

- Different propagating structures, preparation of media
- Vegetative methods of propagation
- Anatomical studies on rooting of cuttings, curing and hardening of rooted cuttings, raised through mist propagation
- Tissue culture techniques including handling and transportation of micropropagules

References

- H. T. HARTMANN, D. E. KESTER, F. T. DAVIES. AND JR. R. L. Geneve Plant Propagation , Principles and Practices,
- R. R. SHARMA, Propagation of Horticultural Crops, Principles and Practices,

- S. RAJAN AND B. L. MARKOSE, Propagation of Horticultural crops,
- J. S. BAL , S. S. GILL AND A. S. SANDHU, Raising Fruit Nursery,
- R.R.SHARMA, Text book of plant propagation and nursery management,

HRT 609 ADVANCES IN NUTRIENT MANAGEMENT OF FRUIT CROPS (1+1)

Objective

To impart comprehensive knowledge about the advances in nutrient management of fruit crops.

Theory

Block 1: Nutrient source and their formulations and management in fruit crops

Unit I: Nutrient sources-Nitrogen, Phosphorus and Potassium fertilizers and manures, essential plant nutrients - functions and deficiency symptoms.

Unit II: Special features of nutrition of fruit crops.

Unit III: Plant and soil analysis as a guide for fertilization of fruit crops. Factors affecting nutrition, scion and stock relationships, effects of nutritional factors on cold hardiness of plants.

Unit IV: Bio-fertilizers and their importance in crop production.

Unit V: Micronutrients – critical limits in soils and plants, factors affecting their availability and correction of their deficiencies.

Unit VI: Controlled release of fertilizers. Nutrients film techniques, fertigation, distribution and effectiveness of the root system. Methods to investigate tree root system.

Unit VII: Fertilizer use efficiency

Unit VIII: Current nutritional problems in fruit crops.

Practicals

- Leaf sampling techniques in various fruit crops.

- Methods of analysis of leaf and soil samples.
- Study of modern instrumental method of analysis.
- Isolation, identification of different species of vesicular arbescular mycorrhiza fungi.
- Pot experiments to study the effect of different microorganisms on growth and nutrient uptake of nursery seedlings, root activity in fruit crops by tracer methods

References

- ANOOP KUMAR SRIVASTAVA, Fruit Crops: Diagnosis and Management of Nutrient Constraints
- PINAKI ACHARYYA, Good management practices for horticultural crops
- N. P. SINGH, Integrated Nutrient Management Supply System
- B. S. CHUNDAWAT, Nutrient Management in Fruit Crops

HRT 610 ADVANCES IN LANDSCAPE GARDENING (1+1)

Objective

To impart comprehensive knowledge about the advances in landscape gardening

Theory

Block 1: Use of advance methods of landscape gardening

Unit I: Modern trends in the use of elements and principles of landscape design.

Unit II: Use of computers in landscape design. Developing computer Aided Design (CADD).

Unit III: Use of database of landscape plants in landscaping of different places.

Unit IV: Use of garden adornment, interior landscaping and xeriscaping, bio-aesthetic planning of urban towns, highways, industrial areas, golf courts and traffic islands.

Unit V: Sources and nature of pollutants, sensitivity and resistivity of plants to air pollutants.

Unit VI: Bonsai, flower arrangement, terrariums, terrace gardening, vertical gardening.

Practical

- Planning and layout of different types of gardens
- Preparation of landscape plants of places of public importance
- Map reading and interpretation
- Making drawings of garden adornments
- Learning the basics in (CADD) for developing a garden landscape plan
- Handling soft landscape materials (AUTOCAD & ARCHICAD)
- GIS as a tool for spatial designing
- Contemporary landscaping
- Monitoring and mapping of pollution with the help of plants
- Planning of urban landscape designs

Reference

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- Bhattacharjee, S. K., 2006, Advances in Ornamental Horticulture. Vols. I-VI. 2. Pointer Publ.
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- LAURIA, A. AND RIES, V. H., 2001, Floriculture – Fundamentals and Practices. AgrobiosPublishers
- RANDHAWA, G. S. AND MUKHOPADHYAY, A., 1986, Floriculture in India. Allied Publ.
- REDDY, S., JANAKIRAM, B., BALAJI, T., KULKARNI, S. AND MISRA, R. L., 2007, Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

HRT 611 BIOTECHNOLOGY OF FRUIT AND PLANTATION CROPS (1+1)

Objective

To impart comprehensive knowledge about the exploitation of biotechnological applications for improvement of fruit and plantation crops

Theory

Block 1 : Introduction to biotechnology

Unit I: Definition and branches of biotechnology, plant tissue Culture, historic perspective

Unit II: Tissue culture methods *viz.,* micro propagation, meristem culture, protoplast culture, cell suspension culture, embryoculture, somatic hybridization, ovule culture, anther culture, *In-vitro* pollination etc. Methods followed for *in vitro* production of secondary metabolites.

Unit III: Application of molecular markers, Molecular markers study using RAPD, SSRs, AFLP etc.

Unit IV: Transformation techniques and bio-safety issues, detection of transgenics by PCR, western blot method.

Unit V: Use of biotechnology for the production of bio-agents and bio-fertilizers.

Block 2: Exploitation of biotechnological applications for improvement of fruit crops

Unit I: Mango, Banana, Papaya,

Unit II: Citrus, Grape and Pineapple

Unit III: Apple, Plum, Apricot

Unit IV: Minor fruits - Pomegranate, Jack fruit, Avocado, Strawberry.

Block 3: Exploitation of biotechnological applications for improvement of plantation crops.

Unit I: Coconut, Arecanut and Oil palm other plantation crops.

Unit II: Coffee, Tea

Unit III: Cardamom, Pepper, Ginger.

Practicals

- Preparation of plant tissue culture media
- Aseptic initiation of plant cultures using various explants
- Production of secondary metabolites using callus and suspension cultures
- Plant genomics DNA isolation from leaf samples
- PCR amplification using RAPD/SSR/SARP markers
- Gel electrophoresis and documentation
- Data scoring and analysis using softwares
- Data interpretation and drawing conclusions

Reference

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- SINGH, B. D. AND SINGH, A. K., 2015, Marker-Assisted Plant Breeding: Principles and Practices Springer Nature Switzerland AG. Springer is part of Springer Nature .
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HRT 612 BIOTECHNOLOGY OF VEGETABLE AND FLOWER CROPS (1+1)

Objective

To impart comprehensive knowledge about the exploitation of biotechnological applications for improvement of vegetable and flower crops

Theory

Block 1: Introduction to Bio-technology

Unit I: Definition and branches of biotechnology.

Unit II: Tissue culture methods *viz.,* micro propagation, meristem culture, protoplast culture, cell suspension culture, embryoculture, somatic hybridization, ovule culture, anther culture, *In-vitro* pollination etc.

Unit III: Application of molecular markers, Molecular markers study using RAPD, SSRs, AFLP etc.

Unit IV: Transformation techniques and bio-safety issues, detection of transgenics by PCR, western blot method.

Unit V: Use of biotechnology for the production of bio-agents and bio-fertilizers.

Block 2: Exploitation of biotechnological applications for improvement of vegetable crops

Unit I: Tomato, Potato, Eggplant, Hot and Sweet peppers

Unit II: Carrot, Radish, Sweet Potato

Unit III: Onion, Garlic

Unit IV: Cucumber, Gherkin, Watermelon, Muskmelon, Bitter gourd

Unit V: Cabbage, Cauliflower

Block 3: Exploitation of biotechnological applications for improvement of flower crops.

Unit I: Rose, Chrysanthemum

Unit II: Anthurium, Orchids

Unit III: Carnation, Gerbera

Unit IV: Gladiolus, Bird of Paradise

Practicals

- Introduction to biotechnology laboratory,
- Preparation and sterilization of plant tissue with media,
- Establishment *In-vitro* culture in vegetables and flower crops.
- Molecular markers study using RAPD, SSRs, AFLP etc.,

- Plant transformation techniques, detection of transgenics by PCR, western blot method.

Reference

- BOOPATHI. AND N. MANIKANDA., 2013, Genetic Mapping and Marker Assisted Selection:Basics, Practice and Benefits Springer Nature Switzerland AG. Springer is part of Springer Nature.
- SINGH, B. D. AND SINGH, A. K., 2015, Marker-Assisted Plant Breeding: Principles and Practices Springer Nature Switzerland AG. Springer is part of Springer Nature .
- V. A. PARTHASARATHY, T. K. BOSE AND P. C. DEKA, 2001, Biotechnology of Horticultural Crops Volume -1 and 2: Naya Prokash
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- PRASAD AND KUMAR, 2011, Impact of Plant Biotechnology on Horticulture.Published by Agrobios India
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- SINGH, B. D., 1990, Plant Breeding. Kalyani Publishers
- KALLOO, G. AND B. O. BERGH., 1993, Genetic improvement of vegetable crops. Elsevier Ltd 3.
- PETER, K.V. AND T. PRADEEPKUMAR., 2008, Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.
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Ph.D. in Microbiology

Course Code	Course Title	Credit Hours
MIC601	Improvement in Fermentation Technology	3(2+1)
MIC 602	Microbial Physiology and Regulation	2(2+0)
MIC 603	Recent developments in Soil Microbiology	2(2+0)
MIC 604	Recent approaches in Environmental Microbiology	2(2+0)
MIC 605	Plant-Microbe Interactions	3(2+1)
MIC 606	Microorganisms in Biofuels and Bioenergy Production	3(2+1)
MIC 607	Microbial Management of Organic Wastes and Xenobiotics	2(1+1)
MIC 608	Antibiotics in Agriculture and Allied Fields	3(2+1)
	Total	**20 (15+5)**
MIC 680	Qualifying Examination	3 (0+3)
MIC 681	Seminar - I	1 (0+1)
MIC 682	Seminar - II	1 (0+1)
MIC 683	Teaching Assistantship - I	1 (0+1)
MIC 684	Teaching Assistantship - II	1 (0+1)
MIC 691	Research - I	18 (0+18)
MIC 692	Research - II	18 (0+18)
MIC 693	Research - III	18 (0+18)
MIC 694	Research - IV	18 (0+18)

MIC 601 IMPROVEMENT IN FERMENTATION TECHNOLOGY (2+1)

Objectives

1. To enlighten the students on basics of fermentation, metabolic engineering, fermentor designs and downstream processing.
2. To inculcate the skills to operate fermentors.
3. To introduce the students to broad coverage of a diverse field of fermentation technologies and to provide an understanding of the exploitation of microorganisms in the manufacture of bio products.

Theory

Block 1: Rise of Fermentation Technology

Unit 1: Developments in Fermentation

Definition of fermentation – rise of fermentation technology – current trends in fermentation industry – scope and importance of fermentation technology.

Unit 2: Types of fermentors

Continuous, batch and fed batch culture –anaerobic fermentation - range of fermentation process – microbial growth cycle – diauxic growth – growth kinetics - substrate uptake kinetics (Jacob and Monod) - primary and secondary metabolites –future prospects of fermentation microbiology.

Block 2: Fermentor

Unit 1: Components of fermentor and use

Peripheral parts and accessories – alternative vessel designs – containment in fermentation – fermentor preparation and use - aeration and agitation – instrumentation and control – biosensors in monitoring – computer applications in fermentation technology

Block 3: Fermentation Process

Unit 1: Types of Fermentation

Solid state and submerged fermentation – acidic/alcoholic fermentation - recovery of product – effluent treatment – Economics of fermentation

Block 4: Recombinant Strategies Followed

Unit 1: Strategies for isolation of industrially important microbes

New strategies for isolation of industrially important microbes and their genetic manipulations; Antibiotic fermentation research; steroid transformation; Yeast technology–classification, genetics, strain improvement for brewing, baking and distilleries

Practicals

Studying the various components of fermentor

Acquaintance with different types of fermentors

Sterilization and operating procedures

Designing the production medium

Isolation and purification of industrially important microbes

Genetic manipulations in microbes for brewing, baking etc,

Fermentation by improved strains of yeast for alcohol production

Microbial production of enzymes by solid state fermentation

Microbial production of important antibiotics

Bio-remediation of industrial effluents

Visit to fermentation industries

References

- STANBURY, P. F, WHITAKER, A. AND HALL, S. J. *Principles of Fermentation Technology*, Second edition
- ADVANCES IN FERMENTATION TECHNOLOGY-(E d s) Pandey, A., Larroche, C., Soccol, C. R. and Dussap, C. G., 2008, Asia tech Publ, Inc.
- ELMANSI, E. M. T AND BRYCE, C. F. A. *Fermentation Microbiology and Biotechnology*
- ELMANSI, E. M. T., BRYCE, C. F. A., Demain A L and AllmanA R. *Fermentation Technology –Microbiology and Biotechnology*
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- STANBURY, P. F. AND WHITAKER, A., 1987. *Principles of Fermentation Technology*. Pergamon Press.

MIC 602 MICROBIAL PHYSIOLOGY AND REGULATION (2+0)

Objectives

1. To acquaint students with current topics in molecular microbiology and regulatory systems.
2. To impart knowledge about the synthesis of biomolecules in microorganisms by various pathways and their regulation

Theory

Block 1: Historical Evolution of Microbial Physiology

Unit 1: **Molecular aspects of various cell component**

Origin, evolution, structure, function and molecular aspects of various cell components. Differentiation in bacteria, slime molds, yeasts. Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria.

Block 2: Regulation and Pathways

Unit 1: **Regulatory pathways**

Regulation of initiation, termination and anti- termination of transcription. Global regulation and differentiation by sigma factor. Regulatory controls in bacteria - inducible and biosynthetic pathways. Oxidative stress control. Fermentative and respiratory regulatory pathways.

Unit 2: **Regulatory control**

Ribosomal RNA and ribosomal proteins regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression. Biosynthesis of micro molecules (Nucleotides and Amino acids) macromolecules (DNA, RNA, Proteins) Global nitrogen control and regulation of nitrogen fixation.

Unit 3: Current topics

Topics of current interest in molecular microbiology and regulatory systems.

References

Websites

- https://www.frontiersin.org/journals/microbiology/sections/ microbial physiology andmeta bolism
- https://www.sciencedirect.com/bookseries/advances-in-microbial-physiology
- https://www.researchgate.net/journal/0065-2911_ Advances_ in_ Microbial_Physiology
- https://bmb.psu.edu/undergraduate/courses/course-archive/2016/ fall-2016/microbiology-micrb/micrb-401-fall-2016/micrb-401-microbial-physiology-and-structure
- Selected articles from journals.

MIC 603 RECENT DEVELOPMENTS IN SOIL MICROBIOLOGY (2 +0)

Objectives

1. To appraise the students of the latest trends in soil microbiology like ecology and diversity, role in soil with particular reference to soil fertility, organic matter decomposition, biological control and bioremediation of polluted soils.

Theory

Block 1: Recent Developments in Soil Microbiology

Unit 1: Ecology and diversity of microorganisms

Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms. Interaction between agricultural chemicals, pollutants and soil microorganism.

Unit 2: **Role of microorganisms in the soil**

Successions and transformation of organic matter; Role of microorganisms in soil fertility. Soil health and quality: Microbial indicators.

Unit 3: **Bioremediation**

Bioremediation of polluted soils; Biological control. Other topics of current interest.

References

- https://www.springer.com/in/book/9789811073793
- https://www.researchgate.net/publication/322952969_ Advances_ in_ Soil_ Microbiology_ Recent_ Trends_ and_ Future_ Prospects_ Volume_2_Soil-Microbe-Plant_Interaction.
- Selected articles from journals.

MIC 604 RECENT APPROACHES IN ENVIRONMENTALMICROBIOLOGY (2+0)

Objectives

To apprise the students of the role of microbiology in environment management sustainable eco-system and human welfare.

Theory

Block 1: Recent Environmental Issues

Unit 1: **Basic concept and environmental issues**

Types of environmental pollution; problems arising from high-input agricultural residues. Air and water pollution.

Unit 2: **Methodology of environmental management**

Wastewater treatment -physical, chemical, biological microbial processes; the need for water and natural resource.

Unit 3: Microbial waste treatment

Microbiology and use of microorganisms in waste treatment; biodegradation; degradation of xenobiotic, surfactants; bioremediation of soil and water contaminated with oils, pesticides & toxic chemicals, detergents, *etc*.; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc*.); anaerobic processes: digestion, filtration, *etc*.

Block 2: Energy Harnessing from Organic Waste

Unit 1: **Pollution through conventional fuel**

Conventional fuels and their environmental impact.

Unit 2: **Renewable sources of energy**

Energy from solid waste; biogas; land filling, microbial hydrogen production; use of agro-industrial waste, agricultural waste for sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture, *etc*.

Block 3: Treatment of Waste for Safe Disposal

Unit 1: **Disposal of domestic and industrial wastes**

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms.

Unit 2: **Global environmental problems**

Ozone depletion, UV-B, greenhouse effects and acid rain; biodiversity and its conservation; Microbial and biotechnological approaches for the management of environmental problems.

References

- EVANS, G. M. AND FURLONG, J. C., 2002. *Environmental Biotechnology: Theory and Application*. Wiley International.
- JORDENING, H. J. AND WINTER, J., 2006. *Environmental Biotechnology: Concepts and Applications*. Wiley-VCH Verlag.

Websites

- https://www.springer.com/series/11961
- http://microbiology.ucsc.edu.
- http://www.asm.org

MIC 605 PLANT MICROBE INTERACTIONS (2+1)

Objectives

1. To familiarize the students with the biochemical and biophysical mechanisms, genetics, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces of beneficial and pathogenic plant microbe interactions.
2. To provide knowledge on molecular analysis of relevant factors in the plant and microbes, and components that modulate plant-microbe interactions for soil and plant health for sustaining crop productivity.

Theory

Block 1: Types of Ecosystems and Microbial Interaction

Unit 1: Different interfaces of interactions

Plant-microbe, microbe-microbe, soil-microbe, soil-plant-microbe interactions leading to symbiotic (legume - *Rhizobium*, *Frankia* - Casuarina, *Azolla-Anabaena*) and mycorrhiza: associative, endophytic and pathogenic interactions.

Unit 2: Ecosystem- Concept and Dynamics

Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow, Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, T- RFLP.

Block 2: Signaling and Interaction among microbes

Unit 1: Microbial interaction

Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.

Block 3: Genomic and Proteomic Study in Plant Microbe Interaction

Unit 1: Methodology/resources in plant-microbe interaction

Methodology to study plant-microbe interaction, biosensors, transcriptome profiling, metabolic profiling, genomics, and proteomics

Induced systemic resistance against pathogens and tolerance against abiotic stress: Molecular basis; Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants

Practicals

- Phylochip based microbial community analyses - Endophytic and phyllosphere microbial community
- PCR-DGGE-Rhizosecretion
- Secretome - FTIR, HPLC
- Multifunctional protein identification and characteriation-2DE, MALDI- TOF
- Examination of mycorrhizal infection in roots of different plants.
- Characterization of PGPR; Quantification of siderophores, HCN and IAA.

References

- KOSUGE, T. AND NESTER, E. W., 1989. *Plant Microbe Interactions: Molecular and Genetic Perspectives*, Vol. I-IV, Mc Graw Hill.
- PAUL ELDOR, A., 2007. *Soil Microbiology, Ecology and Biochemistry*
- ROBERT, L. TATE, III., 1995. *Soil Microbiology*, John Wiley & Sons,INC.
- SYLVIA, DAVID, M., FUHRMANN, T. A., HARTEL, P. G. AND ZUBERER, D. A., 2005. *Principles and Applications in Soil Microbiology* (II ndEdition).
- VERMA,D. P. S. ANDKOHN,T. H. 1984.*GenesinvolvedinMicrobe-PlantInteractions*,Springer-Verlag

MIC 606 MICROORGANISMS IN BIO-FUELS AND BIO-ENERGY PRODUCTION (2+1)

Objectives

1. To appraise about the role of microorganisms in bio-conversions of organic residues to valuable products.

2. To demonstrate bio methanation technique using anaerobic systems.

3. To impart the knowledge of use of microorganisms in bio fuel production.

Theory

Block 1

Unit 1: **Methane production**

Microbial consortia and biological aspects of methane fermentation: Hydrolysis and acidogenesis; Acetogenesis and dehydrogenation;

Unit 2: **Methanogenesis**

Development in bioreactor technology; Upflow anaerobic sludge blanket (UASB); Upflow anaerobic filter process (UAFP); Anaerobic fluidized- bed reactor (AFBR); Two-phase methane fermentation processes.

Block 2

Unit1: **Bioethanol from biomass**

Saccharification of cellulosic waste materials: Pre-treatment of cellulosic waste. Saccharification; Recovery and re-use of cellulose; Screening of cellulose - producing microorganisms.

Unit 2: **Microbial-based biofuels**

Microbial bioreactors producing H_2 for conventional fuel. Integrated microbial – based bio-fuels producing electro-chemically active metabolites. Oil production: Oil substitutes from biomass. Micro-algae as biological sources of lipids and hydrocarbons. Future prospects in mechanisms of crude oil formation by natural phenomena.

Practical

Microbial consortia and biological aspects of methane fermentation

Utilization of organic materials for hydrogen production

Saccharification of cellulose waste materials - corn, reverse osmosis membrane technology

Use of immobilized yeast cells in alcohol fermentation

Bio-photolysis of water by micro-algae and cyanobacteria

Cultivation of microalgae as biological sources of lipids and hydrocarbons

References

- KALIA, V., PRASUNKUMAR, (Eds), 2017, Microbial Applications-I: Bio-remediation and Bioenergy. Publ: Springer International Publishing..
- SRIVASTAVA, N., SRIVASTAVA, M., MISHRA, P.K.,AND GUPTA, V., (Eds.) 2020, Microbial Strategies for Techno-economic Bio-fuels Production. Publ: Springer Nature , Singapore.
- GOSSET, G., 2017, Engineering of Microorganisms for the Production of Chemicals and Bio-fuels from Renewable Resources. Springer International Publishing.
- MISHRA AND SNEHASHISH, 2019, Biogas Technology, New India Publishing Agency-Nipa.

MIC 607 MICROBIAL MANAGEMENT OF ORGANIC WASTES AND XENOBIOTICS (1+1)

Objectives

1. To demonstrate microbial degradation of organic residues and in treatment of polluted water for reuse. .
2. To apprise the mechanisms of eco-friendly approaches to reduce xenobiotic contaminants in an environment by microbial degradation.

Block 1

Unit 1: Organic wastes in tropical, temperate and forest ecosystems

Aerobic and anaerobic decomposition – mechanism and factors influencing degradation. Management of farm waste – methods of composting, microbiology of composting, factors influencing decomposition.

Unit 2: Liquid waste management

sewage treatment process, recycling of sewage water. Treatment of effluents from paper, sugar, distillery & tannery industries.

Urban solid waste management – composition of wastes; degradation strategies and enrichment technology – Vermi composting, sanitary landfill method. Production of single cell protein & mushroom.

Block 2

Unit 1: **Biodegradation of xeno biotics**

Hydrocarbons including petroleum hydrocarbons; Halogenated aliphatic compounds; Halogenated aromatic compounds; Non-chlorinated pesticides and herbicides; Explosive chemicals, TNX, TDX;

Unit 2: Genetic basis of biodegradation

enhancing bacterial degradation genes through molecular biology. Application of biodegradation and bioremediation – concept of bioremediation. Soil inoculation with degrading bacteria; Monitoring bacteria introduced into the soil.

Practical

Qualitative and quantitative enumeration of microorganisms in organic wastes.

Study of cellulolytic and lignolytic microbes.

Microbial succession during composting.

Production of single cell protein and mushroom. Preparation of Vermicompost.

Development of enrichment cultures for degradation of pesticides in soil.

Extraction of pesticides from soil samples. Separation of metabolites by TLC.

References

- ALEXANDER, M., 1994, Biodegradation and Bioremediation, San Diego CA. Academic Press.
- REES, R. M, BALL, B., WATSON AND CAMPBELL, C., (Eds), 2000, Sustainable Management of Soil Organic Matter, Publ: CABI.
- MAGDOFF, F. AND WEIL, R. R. (Eds.) 2004, Soil Organic Matter in Sustainable Agriculture (1st ed.). C R C Press. https://doi.org/10.1201/9780203496374
- HASANUZZAMAN, M. , NARASIMHA, M. AND VARA PRASAD, (Eds) 2020, Handbook of Bioremediation, Physiological, Molecular and Biotechnological Interventions, Publ: Elsivier
- NAOFUMI SHIOMI, 2015, Advances in Bioremediation of Wastewater and Polluted Soil.

MIC 608 ANTIBIOTICS IN AGRICULTURE AND ALLIED SCIENCES (2+1)

Objectives

1. To impart in depth knowledge of developments in chemotherapy, search for antibiotics.
2. To acquaint with concepts of antimicrobial activities, MIC, MBC and protocols for microbiological assay of new antibiotics.
3. To demonstrate the practical utility of antibiotics in agriculture, vetreinary medicine, food preservation and feed supplements.

Block 1

Unit 1: Historical developments in the study of antibiotics

Selective toxicity, Use of salvarsan, atoxyl, prontosil and silver compounds in treatment of infections, Antimicrobial compounds from plants, animals, insects, Discovery of antibiotics from microorganisms,

Unit 2: **Definition of Antibiotics**

Bacteriocins, Disinfectants, Antiseptics, Sanitizer, Bile salts, Preservatives, Chemotherapeutic agents, detergents.

Unit 3: **Chemotherapeutic agents**

Their properties concentrations and mode of actions (Phenol, H_2O_2, $KMNO_4$, I_2, Cl_2, Fl_2, C_2H_5OH, Mercurites, Thymol, Chorophenols, Salicylic acid).Approaches to chemotherapy - Biological competition. Para Amino Benzoic Acid (PABA) and Sulpha drugs.

Block 2

Unit 1: **Classification of antibiotics**

Structure, origin, source, physico - chemical properties, spectrum of activity, biosynthesis and mode of actions.

Unit 2: Industrial production of antibiotics Microbiological assay – Assessment of new antibiotics - Determination of MIC, MBC.

Unit 3: Antibiotic resistance- types – vertical /horizontal- *Pseudomonas aeruginosa* and *Staphylococcus aureus* (MRSA)

Block 3

Unit 1: Use of antibiotics in agriculture and its impact on soil, water and manures.

Unit 2: Control of fungal plant and animal pathogensusing antibiotics

Unit 3: Antibiotics as food preservatives and in growth promotion of animals.

Practicals

1. Isolation of antagonistic microorganisms by crowded plate method
2. Extraction of antimicrobial principle and testing by agar cup, disc diffusion and bio mass methods

3. Determination of MIC and MBC
4. Isolation of antibiotic resistant mutants.

References

- ADAMS, J., 2017, *Antibiotics*. Cavendish Square Publishing, LLC.
- DOUGHERTY, T. J. AND PUCCI, M. J. Eds., 2011, *Antibiotic discovery and development*. Springer Science & Business Media.
- MOATS, W. A., 1986, Agricultural uses of antibiotics. In: *ACS symposium series (USA)*. American Chemical Society.
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- KHACHATOURIANS, G. G., 1998, Agricultural use of antibiotics and the evolution and transfer of antibiotic-resistant bacteria. *Cmaj*, **159**(9): 1129-1136.
- KUMAR, K., GUPTA, S.C., CHANDER, Y. AND SINGH, A.K., 2005, Antibiotic use in agriculture and its impact on the terrestrial environment. *Adv. Agron.* **87:**1-54.
- MANYI-LOH, C., MAMPHWELI, S., MEYER, E. AND OKOH, A., 2018, Antibiotic use in agriculture and its consequential resistance in environmental sources: potential public health implications. *Mol.*, **23**(4): 795-798.
- TAYLOR, P. AND REEDER, R., 2020, Antibiotic use on crops in low and middle-income countries based on recommendations made by agricultural advisors. *CABI Agri. Biosci.* **1**(1); 1-14.

Ph.D. in Molecular Biology and Biotechnology

Course Code	Course Title	Credit Hours
MBB 601	Plant Molecular Biology	3 (3+0)
MBB 602	Plant Genome Engineering	3 (3+0)
MBB 603	Plant Omics and Molecular Breeding	3 (3+0)
MBB 604	Commercial Plant Tissue Culture	2 (2+0)
MBB 605	Plant Microbe Interaction	2 (2+0)
MBB 606	RNA Biology	1 (1+0)
MBB 607	Plant Hormones and Signaling	2 (2+0)
MBB 608	Computational and Statistical Tools in Biotechnology	3 (2+1)
MBB 609	Advances in Biofuel Biotechnology	2 (1+1)
	Total	**21 (19+2)**
MBB 680	Qualifying Examination	3 (0+3)
MBB 681	Seminar - I	1 (0+1)
MBB 682	Seminar - II	1 (0+1)
MBB 683	Teaching Assistantship - I	1 (0+1)
MBB 684	Teaching Assistantship - II	1 (0+1)
MBB 691	Research - I	18 (0+18)
MBB 692	Research - II	18 (0+18)
MBB 693	Research - III	18 (0+18)
MBB 694	Research - IV	18 (0+18)

MBB 601 PLANT MOLECULAR BIOLOGY (3+0)

Objective

To provide in depth knowledge of recent developments of plant molecular biology and applications.

To discuss case studies and success stories in agriculture and industry

Theory

Block I: Model systems and genome organization

Unit 1: Plant biology model systems and genetic approaches

Model Systems in plant biology (*Arabidopsis*, Rice, etc.) Forward and Reverse genetic approaches.

Unit 2: Genome organization

Organization expression and interaction of nuclear, mitochondrial and chloroplast genomes. Cytoplasmic male sterility.

Block II: Gene regulation and process of plant development.

Unit 1: Types of regulation of gene expression and regulatory elements

Transcriptional and Post-transcriptional Regulation of Gene Expression, Isolation of promoters and other regulatory elements, RNA interference, Transcriptional Gene Silencing, Transcript and Protein Analysis.

Unit 2: Processes and role of hormones in plant developmental process

Plant developmental processes, ABC Model of floral development, Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development. Regulation of flowering, plant photoreceptors and light signal transduction, vernalization, circadian Rhythms.

Block III: Stress responses, plant microbe interaction and PCD

Unit 1: Biotic and abiotic stresses.

Abiotic stress responses: Salt, cold, heat and drought. Biotic stress responses.

Unit 2: Molecular biology of plant microbe interaction

Molecular biology of Plant-pathogen Interactions. Molecular biology of *Rhizobium* and *Agrobacterium*- Plant interaction.

Unit 3: Programmed cell death

Role of programmed Cell Death in development and defense.

References

- BUCHANAN, B. B., GRUISSEM, W. AND JONES, R., 2015, Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley and Blackwell Publications.
- SLATER, A., SCOTT, N. W. AND FOWLER, M. R., 2003, The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press.
- WALKER, J. M. AND RAPLEY, R., 2008, Plant Biotechnology and Genetics: Principles, Techniques and Applications.

MBB 602 PLANT GENOME ENGINEERING (3+0)

Objective

To discuss the specialized topics and advances in field of genetic engineering and application of molecular tools in breeding of specific crops.

Block I: Crop improvement methods and applications

Unit 1: Types and advances in crop improvement

Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation and genomic tools for crop improvement.

Unit 2: Genetic engineering for biotic and abiotic stresses

Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses;

Unit 3: Genetic engineering for increasing crop productivity and quality

Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc.); edible vaccines, etc.

Block II: Advances in plant transformation and gene expression

Unit 1: Recent strategies of plant transformation.

Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement.

Unit 2: Regulation of gene expression

Regulated and tissue-specific expression of transgenes for crop improvement.

Block III: Gene stacking, Genome editing and field studies of transgenic plants

Unit 1: Principles and methods of gene stacking and genome editing

Gene stacking; Pathway engineering; Marker-free transgenic development strategies; Genome editing: principles and methods, Development of genome edited plants; High throughput phenotyping of transgenic plants.

Unit 2: Field studies and risk assessment of transgenic crops

Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

References

- CHRISTOU, P. AND KLEE, H., 2004, Handbook of Plant Biotechnology. John Wiley & Sons.
- STEWART JR, C. N., 2016, Plant Biotechnology and Genetics: Principles, Techniques, and Applications. John Wiley & Sons.
- KIRAKOSYAN, A. AND KAUFMAN, P. B., 2009, Recent Advances in Plant Biotechnology p. 409. Dordrecht: Springer.

MBB 603 PLANT OMICS AND MOLECULAR BREEDING (3+0)

Objective

To discuss the specialized topics and advances in field of genomics and genomics assisted molecular breeding.

Theory

Block I: QTLS, genome mapping and genotyping

Unit 1: QTLs and mapping of genes

Complex traits and genetic architecture, Mapping genes and QTLs, statistical concepts in QTL mapping,

Unit 2: Genotyping and genome mapping

High-throughput genotyping using automated platforms, genetic and physical mapping of genomes.

Unit 3: Analysis and case studies of QTLs

Study of population structure and kinship, association genetic analysis of QTL, case studies on QTL mapping using different approaches, map-based of cloning genes and QTLs – case studies.

Block II: Marker Assisted Breeding

Unit 1: Principles and methods of MAB

Marker Assisted Breeding (MAB): Principles and methods, marker assisted foreground and background selection, marker assisted recurrent selection.

Unit 2: Case studies and economics of MAB

Whole genome selection, case studies in MAS, requirement for successful marker assisted breeding, cost of MAB.

Block III: Next generation sequencing, mutagenesis in genomics, Analysis of proteome data and metabolome

Unit 1: Next Generation Sequencing

Concepts and methods of next generation sequencing (NGS), assembly and annotation of NGS data, genome resequencing, DNA sequence comparison, annotation and gene prediction.

Unit 2: Mutagenesis in functional genomics

Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing.

Unit 3: Methylome and analysis of proteomic data

Study of methylome and its significance, proteome analysis using mass spectrometry, crystallography and NMR, analysis of proteome data, study of protein- protein interactions.

Unit 4: Metabolome and its analysis

Study of the metabolome, use of 1D/2D NMR and MS in metabolome analysis, multivariate analysis and identification of metabolite as biomarkers, study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome.

References

- SPEICHER, D. W., (Ed.), 2004, Proteome analysis: interpreting the genome. Elsevier.
- TOMITA, M. AND NISHIOKA, T., (Eds.), 2006, Metabolomics: the frontier of systems biology. Springer Science and Business Media.
- HORST, L. AND WENZEL, G., (Eds.), 2007, Molecular marker systems in plant breeding and crop improvement (Vol. 55). Springer Science and Business Media.
- STEWART, C. N., 2008, Plant Biotechnology and Genetics: Principles, Techniques and Applications.
- SINGH, B. D. AND SINGH, A. K., 2015, Marker-Assisted Plant Breeding: Principles and Practices Springer (India) Pvt. Ltd.

MBB 604 COMMERCIAL PLANT TISSUE CULTURE (2+0)

Objective

1. To provide awareness into development of commercial scale plant tissue culture units.
2. To provide an insight into the commercial applications of plant tissue culture in agriculture, medicine and industry.
3. To educate about biosafety, regulatory as well as entrepreneurship opportunities

Theory

Block I: Micropropagation and secondary metabolite production

Unit I: Micropropagation of plants and marketing

Micro-propagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

Unit II: Secondary metabolite production and its applications

Production of useful compounds via, biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry.

Block II: Transgenic plants, project planning and entrepreneurship

Unit 1: Transgenic plant development and biosafety issues

Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethical issues; management and commercialization.

Unit 2: Project planning, Entrepreneurship and success stories of plant tissue culture

Project planning and preparation, economics (entrepreneurship, cost profit ratio), government policies (incubators, different facilitation projects, loan opportunities). Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

References

- HONDA, H., LIU, C., KOBAYASHI, T., 2001, Large-Scale Plant Micropropagation. In: Zhong J.J. *et al*. (eds) Plant Cells. Advances in Biochemical Engineering/ Biotechnology, vol 72. Springer, Berlin, Heidelberg.
- BHOJWANI, S. S. AND RAZDAN, M. K., 1986, Plant tissue culture: theory and practice (Vol. 5). Elsevier.

MBB 605 PLANT MICROBE INTERACTION (2+0)

Objective

To discuss the specialized topics and advances in field of plant microbe interaction for understanding their potential in enhancing crop growth and development.

Theory

Block I: Microbial communities and Molecular aspects of plant-microbe interactions

Unit 1: Microbial communities and population interactions

Microbial communities in the soil and atmosphere, Community dynamics and population interactions with particular reference to plant–microbe and microbe- microbe interactions leading to symbiotic, associative, endophytic and pathogenic interactions, effects of microorganisms on plants, effects of plants on microorganisms.

Unit 2: Molecular aspects of plant growth promoting microbes

Recognition processes and signal exchange, Molecular aspects of Plant Growth Promoting Rhizobacteria (PGPR), Symbiotic diazotrophs: Rhizobia and association with legumes. Mycorrhizal associations: Ectomycorrhizae, Endomycorrhizae with particular emphasis to AM fungi, Ectendomycorrhizae. Biocontrol agents and their action, endophytes associations.

Block II: Nutritional and immunity aspects of plant-microbes

Unit 1: Nutritional and defense responses in plants

Enzymes, toxins, pili, siderophores, secretion systems of microbes and plants determining soil health, nutrient availability and uptake defense responses in plants: PAMP-triggered immunity, effector-triggered susceptibility, qualitative resistance, R genes, structure and function, effector-triggered immunity.

Unit 2: PCD, Plant hormones in immunity and plant parasite interaction

Regulation of plant cell death, plant hormones in immunity, Plant parasite interactions and its molecular basis and impact on plant functions including photosynthesis, respiration, nitrogen metabolism and translocation.

Block III: Microbiome, phytobiomes, industrial applications and plant resistance mechanism.

Unit 1: Microbiome, phytobiomes and its industrial applications

Quorum sensing in bacteria, understanding Microbiome, phytobiomes, dynamics, Applied and ecological aspects of symbioses and pathogen defense, techniques to study plant microbe interaction including microbe tagging, metagenomics and use of organismal databases to identify genes involved in interactions. Industrial application of agriculturally important microbes.

Unit 2: Plant resistance mechanism against pathogens

Resistance mechanisms against attack by plant pathogens, gene-for-gene interactions; induced resistance; non-host resistance. Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Plant and microbial gene expression and signal exchange, specific regulators for different interactions including transgenic plants. Recognition mechanism and signal transduction during plant - pathogen interaction.

References

- RANGASWAMY, G. BHAGYARAJ., 1993, Agricultural Microbiology, Prentice Hall India.

- STACEY, G. AND KEEN, N. T., (Eds.), 1996, Plant-microbe interactions. Springer Science & Business Media.

- DICKINSON M., 2005, Molecular Plant Pathology. Bios Scientific Press, Taylor and Francis group.
- KOSUGE, T. AND NESTER, E. W., 1989,. Plant-Microbe Interactions: Molecular and Genetic Perspectives. Vols. I-IV. McGraw Hill.
- GONZALEZ, M. B. R. AND GONZALEZ-LOPEZ J., (Eds.), 2013, Beneficial plant-microbial interactions: ecology and applications. CRC press.

MBB 606 RNA BIOLOGY (1+0)

Objective

❖ To discuss the specialized topics and advances in the field of Plant RNAs, their structure and role in cellular regulation and scope for crop improvement.

Theory

Block 1: RNA structure analysis, its regulation and translation

Unit I: Structural analysis of RNA and genome evolution

RNA structure, functional evolution: RNA structure, types of RNA and function; Genome evolution- RNA as genetic material to regulatory molecule, Non-Coding RNAs, structure, function and regulation

Unit 2: RNA synthesis, regulation and translation

RNA synthesis, processing and regulation: transcription and its regulation in prokaryotes and eukaryotes; RNA splicing and editing; Translation and its regulation in prokaryotes and eukaryotes

Block 2: Advances in genome regulation and epigenetic regulation

Unit 1: Genome regulation and CRISPR-Cas

Genome regulation: Prokaryotic- attenuation, ribozymes, aptamers, ribo-switches, CRISPR Cas; eukaryotic-Exon skipping, nonsense-mediated decay, RNAi, Long non-coding RNA.

Unit 2: Epigenetic regulation and its application

Epigenetic regulation. RNA-based gene silencing technologies and their applications for crop improvement

Reference

- ELLIOTT, D. AND LADOMERY, M., 2017, Molecular biology of RNA. Oxford University Press.
- RAO, M. R. S., (Ed.), 2017, Long Non-Coding RNA Biology, Springer.
- DONALD, C. R., HANNON, G., ARES, M. AND NILSEN, T. W., 2011, RNA: A Laboratory Manual, CSHL Press.
- MAAS, S., (Ed.), 2013, RNA Editing: Current Research and Future Trends. Horizon Scientific Press.

MBB 607 PLANT HORMONES AND SIGNALING (2+0)

Objective

- ❖ To provide in-depth knowledge of plant hormone and their role in plant growth and development.

Theory

Block I: Hormones and its role in plant growth and development

Unit 1: Hormone biosynthesis, metabolism and its regulation: Auxin biosynthesis and metabolism, Gibberellin biosynthesis and Inactivation, Cytokinin biosynthesis and metabolism, Ethylene biosynthesis, Abscisic acid biosynthesis and metabolism, Brassinosteroid biosynthesis and metabolism. Salicylic acid and jasmonate biosynthesis and metabolism.

Unit II: Functioning of hormones in plant growth and development: Transport of Auxins, induction of vascular tissues by Auxin, hormones and the regulation of water balance, seed development and germination, hormonal control of day length and senescence.

Block II: Hormone Actions and signal transduction

Unit 1: Action of Hormones: Hormones in defense against insects and disease; Role of jasmonates, salicylic acids and peptide hormones for defense, growth, development and reproduction; Methods of plant hormone analysis. NPR 1 dependent Salicylic acid signaling, PAMP and effector triggered immunity, systemic acquired resistance and SA signaling.

Unit 2: Hormone Signal Transduction: Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction, Gibberellin biosynthesis, transport, signal transduction in stem elongation & leaf growth, Ethylene metabolism, perception and signaling in seedling growth and development, Ethylene signal transduction in fruits and flowers, Abscisic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses. Brassinosteroid biosynthesis, catabolism and signal transduction. Strigalactone biosynthesis, transport and signaling in plant parasitism and symbiosis. Methods of plant hormone analysis: Quantitative analysis of plant hormones based on LC/MS.

References

- DAVIES JR. F. *et al.* 2017. Hart Mann and K Rster's. Plant Propagation: Principles and Practices. Pearson.

MBB 608 COMPUTATIONAL AND STATISTICAL TOOLS IN BIOTECHNOLOGY (2+1)

Objective

- ❖ To provide information on basic principles of computational biology and statistical tools used for data analysis.

Theory

Block I: Introduction to molecular biology and statistical techniques

Unit I : Molecular biology principles and genome analysis

Basic molecular biology; Introduction to the basic principles of structure / function analysis of biological molecules; genome analysis;

different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes, etc.)

Unit II: Types of statistical techniques

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack- knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling

Block II: DNA and protein sequencing analysis through bioinformatics tools

Unit 1: DNA sequence analysis

DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools,

Unit 2: Protein sequence analysis

Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics.

Practical (16)

- Different types of databases and database search and retrieval,
- DNA and protein sequence analysis,
- Similarity searching and multiple alignments,
- Gene annotation,
- Phylogenetic analysis,
- Sequence analysis,
- Protein structure prediction,
- Analysis of microarray data,
- Programming languages in bioinformatics.

Reference

- XIONG, J., 2012, Essential Bioinformatics, Cambridge University Press.
- ANDREAS, D. B. AND OUELLETTE, B. F. F., (Eds), 2004,. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins 3rd Edition, Wiley Interscience.
- MOUNT, D., 2004, Bioinformatics: Sequence and Genome Analysis, 2nd Edition. By, CSHL Press.
- AUGEN, J., 2004, Bioinformatics in the Post-Genomic Era: Genome, Transcriptome, Proteome, and Information-Based Medicine.
- GALPERIN, M. Y. AND KOONIN, E. V., (Eds), 2003, Frontiers in Computational Genomics.

MBB 609 ADVANCES IN BIOFUEL BIOTECHNOLOGY (1+1)

Objective

1. To provide knowledge about biofuel and its advantages over fossil fuel and biotechnological tools in modification of plants and microbes to produce biofuel
2. To study different biotechnological strategies in producing chemical free biodiesel.

Theory:

Block I: Biofuel over fossil fuel

Unit I: Introduction to biofuels, types (biogas, biodiesel, ethanol, methanol, hydrogen and butanol) and their advantages over fossil fuel. Energy security, supply and economic sustainability of biofuels.

Unit II: Biotechnological tools in modification of plants for reducing the lignin content, and to increase the fermentable sugars and high biomass yield. Biotechnological approaches for engineering the plants and microbes for biofuel production.

Block II: Production of biodiesels through biotechnological approaches

Unit I: Biodiesel –Production of biodiesel from different oils through esterification and study of different microorganisms for extraction of enzymes to convert the oil to biodiesel. Development of recombinant microbes to increase the efficiency to produce the biodiesel. Purification of biodiesel and biochemical techniques used for characterization of biodiesel.

Unit II: Bioethanol- production of biofuels from commercial, agricultural, industrial, and domestic wastes through biotechnological approaches. Recent advances in metabolic engineering of microorganisms for advancing lignocellulose-derived biofuels. Environmental aspects of ethanol as a biofuel. Hydrogen fuel cell and microbial feed cell.

Practicals

- Utilization of different microbes for extraction of enzymes for production of biodiesel and bioethanol.
- Production of biodiesel from oil through esterification by using chemical and enzymatic method.
- Development of recombinant microbes/enzymes for production of biofuels.
- Biochemical characterization of biofuel and analysis of biodiesel quality by density, kinematic viscosity, GCMS and other techniques.

References

- ECKERT, C, A. AND TRINH, C, T., 2016, Biotechnology for Biofuel production and Optimization, Elsevier,
- BERNARDES, M. A. D. S., 2011, Biofuel production – recent developments and prospects, In Tech.
- JOSHI, A, VERMA, K. K. D., RAJPUT, V., MINKINA, T. AND ARORA, J., 2022, Recent advances in metabolic engineering of microorganisms, Bioengineered.
- LUQUE, R., CAMPELO, J. AND CLARK, J., 2011., Handbook of biofuels production, Woodhead Publishing Limited.

Ph.D. in Plant Pathology

Course Code	Course Title	Credit Hours
PAT 601	Advances in Mycology	3 (2+1)
PAT 602	Advances in Virology	3 (2+1)
PAT 603	Advances in Plant Pathogenic Prokaryotes	3 (2+1)
PAT 604	Molecular Basis of Host-pathogen Interaction	3 (2+1)
PAT 605	Principles and Procedures of Certification	1 (1+0)
PAT 606	Plant Biosecurity and Biosafety	2 (2+0)
PAT 607	Advances in Plant Nematology	3 (2+1)
PAT 608	Seed Pathology	2 (1+1)
	Total	**20 (12+8)**
PAT 680	Qualifying Examination	3 (0+3)
PAT 681	Seminar - I	1 (0+1)
PAT 682	Seminar - II	1 (0+1)
PAT 683	Teaching Assistantship - I	1 (0+1)
PAT 684	Teaching Assistantship - II	1 (0+1)
PAT 691	Research - I	18 (0+18)
PAT 692	Research - II	18 (0+18)
PAT 693	Research - III	18 (0+18)
PAT 694	Research - IV	18 (0+18)

PAT 601 ADVANCES IN MYCOLOGY (2+1)

Objectives

To acquaint with the advances in mycology *viz*: Recent classification, conidial ontogeny, population biology and morphological and molecular classification of fungi.

Theory

Block 1- Introduction, importance, history and Recent taxonomy of fungi

Unit 1: General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification.

Unit 2: Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy.

Unit 3: Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.

Block 2- Variability in fungi

Unit 1: Population biology, pathogenic variability/ vegetative compatibility. Heterokaryos is and parasexual cycle.

Unit 2: Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance.

Unit 3: Mechanism of extra-nuclear inheritance. Biodegradation.

Block 3- Physiology and reproduction of fungi

Unit 1: Ultra structures and chemical constituents of fungal cells, functions of cell organelles.

Unit 2: Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms;

Unit 3: Parasitism, symbiosis and commensalism in fungi.

Unit 4: Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles – characterization process and application. Mycotoxins problems and its management.

Practical

- Isolation, purification and identification of cultures, spores and mating type determination;
- Study of conidiogenesis - Phialides, porospores, arthospores
- Study of fruiting bodies in Ascomycotina

- Identification of fungi up to species level
- Study of hyphal anastomosis
- Morphology of representative plant pathogenic genera forms different groups of fungi;
- Molecular characterization of fungi

References

- ALEXOPOULOS, C. J., MIMS, C. W. AND BLACKWELL, M., 1996, Introductory Mycology. John Wiley & Sons, New York.
- DUBE, H. C., 2005, An Introduction to Fungi, 3rd ED.Vikas Publ. House, New Delhi.
- KIRK, P. M., CANNON, P. F., DAVID, J. C. AND STALPERS, J. A. (Eds), 2001, Ainsworth and Bisby's Dictionary of Fungi, 9th Ed., CABI, Wallington.
- MAHESHWARI, R. 2016, Fungi: Experimental Methods in Biology 2ndedn. CRC Press, US
- ULLOA, M. AND HANLIN, R. T., 2000, Illustrated Dictionary of Mycology, APS, St. Paul, Minnesota.
- WEBSTER, J. AND WEBER, R., 2007, Introduction to Fungi, Cambridge University Press, Cambridge.

PAT 602 ADVANCES IN VIROLOGY (2+1)

Objectives

To educate about the advanced techniques and new developments in plant virology

Theory

Block 1: Structure, morphology and evolution of plant viruses

Unit 1: Origin, evolution and interrelationship with animal viruses.

Unit 2: Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells.

Unit 3: Mechanisms leading to the evolution of new viruses / strains: mutation, recombination, pseudo-recombination, component re-assortment, *etc.*

Block 2- Taxonomy of vectors, virus vector relationship and serology

Unit 1: Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors.

Unit 2: Terminologies used inimmunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses.

Unit 3: Immuno/ serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid based assays for detection of plant viruses.

Block 3 Molecular diagnosis, genome organization and replication of plant viruses

Unit 1: Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non PCR based: LAMP, Fluorescent in situhybridization (FISH), dot blot hybridization.

Unit 2: Plant virus genome organization(General properties of plant viral genome- information content, coding and non-coding regions), replication

Unit 3: transcription and translational strategies of pararetro viruses, gemini viruses, tobamo-poty, bromo, cucumo, ilar, tospo viruses, satellite viruses and satellite RNA.

Block 4- Genetic engineering and transgenic plants in plant viruses management

Unit 1: Gene expression, regulation and viral promoters. Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes.

Unit 2: Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials.

Unit 3: Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

Practical

- Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation
- Acquaintance with different serological techniques (i) DAC- ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation and autoradiography
- PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny)
- Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs)

References

- DAVIES,1997, Molecular Plant Virology: Replication and Gene Expression. CRC Press, Florida
- FAUQUET *et al.,* 2005, Virus Taxonomy, VIII Report of ICTV. Academic Press, New York.
- GIBBS, A. AND HARRISON, B., 1976, Plant Virology-The Principles. Edward Arnold, London.
- JONES, P., JONES, P. G. AND SUTTON, J. M., 1997, Plant Molecular Biology: Essential Techniques. John Wiley & Sons, New York.
- KHAN, J. A. AND DIJKSTRA., 2002, Plant Viruses as Molecular Pathogens. Howarh Press, New York.

- MARAMOROSCH, K., MURPHY, F. A. AND SHATKIN, A. J., 1996, Advances in Virus Research. Vol.46. Academic Press, New York.
- PIRONE, T. P. AND SHAW, J. G., 1990, Viral Genes and Plant Pathogenesis, Springer Verlag. New York.
- ROGER HULL, 2002, Mathew's Plant Virology (4th Ed.) Academic Press, New York
- THRESH, J. M., 2006, Advances in Virus Research. Academic Press, New York

PAT 603 ADVANCES IN PLANT PATHOGENIC PROKARYOTES (2+1)

Objectives

To learn about the latest developments in all the plant pathogenic prokaryotes as a whole.

Theory

Block 1: Ultra structure and physiology of plant pathogenic prokaryotes

Unit 1: Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation.

Unit 2: Structure and composition (bacteria) cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili)

Unit 3: Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof Parmas (EMP) pathway, Phosphoketolase Pathway and Entner Doudor off Pathway).

Block 2: Taxonomy and nomenclature of plant pathogenic prokaryotes

Unit 1: Current trends in taxonomy and identification of phytopathogenic prokarya: International code of nomenclature, Polyphasic approach,

Unit 2: New/ special detection methods for identification of bacterial plant pathogens.

Unit 3: Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.

Block 3: Bacterial genetics and Bacteriophages

Unit 1: Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability.

Unit 2: Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal genetransfer, Bacterial Pan-Genome

Unit3: Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, *etc.*

Block 4- **Host pathogen interactions**

Unit 1: Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems

Unit 2: Pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.

Unit 3: Beneficial Prokaryotes -Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defense. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

Practical

- Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, MLST profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteria using species/ pathovarspecific primers

- Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts
- Important and emerging diseases and their management strategies.

References

- DALE, J. W. AND SIMON, P., 2004, Molecular Genetics of Bacteria. John Wiley & Sons, New York
- GARRITY, G. M., KRIEG, N. R. AND BRENNER, D. J., 2006, Bergey's Manual of Systematic Bacteriology; The Proteobacteria. Vol II. Springer Verlag, New York
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- STARR, M. P., 1992, The Prokaryotes. Vol I-IV. Springer Verlag, New York.

PAT 604 MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION (2+1)

Objectives

To understand the concepts of molecular biology and biotechnology in relation to host plant-pathogen interactions.

Theory

Block 1: History, role of biotechnological tools and Importance of host pathogen relationship

Unit 1: History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology.

Unit 2: Basic concepts and principles to study host pathogen relationship.

Unit 3: Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes and their interactions.

Block 2- Plant microbe interactions

Unit 1: Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions.

Unit 2: Plant innate immunity: PAMP/ DAMP.

Unit 3: Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

Block 3- Defense mechanism in Plants

Unit 1: Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance,

Unit 2: Pathogenesis related proteins, phytoalexins and virus induced gene silencing.

Unit 3: Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes.

Unit 4: Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Meta populations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops *vs.* natural populations, Durability of resistance, erosion of quantitative resistance.

Block 4- Variability in plant pathogens

Unit 1: Pathogen population genetics and durability, viruses *vs* cellular pathogens.

Unit 2: Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity.

Unit 3: Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Practical

- Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation
- Gene mapping and marker assisted selection
- Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

References

- CHET, I., 1993, Biotechnology in Plant Disease Control John Wiley & Sons, New York
- GURR, S. J., MC POHERSEN, M. J. AND BOWLOS, D. J., 1992, Molecular Plant Pathology-A Practical Approach. Vol. I & II. Oxford Univ. Press, Oxford.
- MATHEW, J. D., 2003, Molecular Plant Pathology, Bios Scientific Publ., UK
- RONALD, P. C., 2007, Plant-Pathogen Interactions; Methods in Molecular Biology. New Jersey.
- STACEY, G. AND KEEN, T. N. (Eds.), 1996, Plant Mirobe Interactions. Vols. I-III, Chapman & Hall, New York; Vol. IV. APS Press, St.Paul, Minnesota.

PAT 605 PRINCIPLES AND PROCEDURES OF CERTIFICATION (1+0)

Objectives

To acquaint with the certification procedures of seed and planting material.

Theory

Block 1: Seed certification

Unit 1: Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD, *etc.* in certification and quality control.

Unit 2: Case studies of certification systems of USA and Europe.

Unit 3: National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification.

Block 2: Seed health management

Unit 1: Methods for testing genetic identity, physical purity, germination percentage, seed health, *etc.*

Unit 2: Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.

Unit 3: Methods used in certification of seeds, vegetative propagules and in-vitro cultures.

Unit 4: Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

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PAT 606 PLANT BIOSECURITY AND BIOSAFETY (2+0)

Objectives

To facilitate deeper understanding on plant biosecurity and biosafety issues in agricultures.

Theory

Block 1: History and introduction to bio security and bio safety

Unit 1: History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine,Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases.

Unit 2: Introduction and History of biosecurity and its importance.

Unit 3: National Regulatory Mechanism and International Agreements / Conventions, *viz.,* Agreement on Application of Sanitary and Phytosanitary (SPS) Measures.

Block 2: Pest risk analysis and assessment models and information system

Unit 1: World TradeOrganization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system.

Unit 2: Early warning and forecasting system, use of Global PositioningSystem (GPS) and Geographic Information System (GIS) for plant biosecurity,pest/disease and epidemic management,

Unit 3: Strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Block 3: Bio safety, regulatory mechanism and issues

Unit 1: Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications

Unit 2: Issues related to release of genetically modified crops. Emerging/resurgence of pests and diseases in the changing scenario of climatic conditions.

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PAT 607 ADVANCES IN PLANT NEMATOLOGY (2+1)

Objectives

To educate about the advanced techniques and new developments in plant Nematology.

Theory

Block 1: Plant parasitic nematode physiology and interaction with host and other organism

Unit 1: Nematode anatomy, morphology, biology and ecology, Phylogenetic and evolutionary concepts.

Unit 2: Nematode ecology, habitat variations and associated factors influencing nematodes, effects of biotic and abiotic factors on host–nematode interaction,

Unit 3: Studies on the interaction of nematodes with other microorganisms including arthropods.

Unit 4: Molecular, cytogeneticall and serological approaches, fine structures in systematic. Culturing, survival ,adaptive biology and variability.

Block 2: Chemical ecology of plant parasitic nematodes

Unit 1: Sex determination, sensory structures and hierarchies in nematode behavior in pheromones, receptors and host induced stimuli in communications systems.

Unit 2: Genetics of nematode parasitism. Anatomy and ultra structure of plant responses**.**

Unit 3: Plant deferens and incompatibility. Interactions with fungi, bacteria, mycorrhiza, other nematodes, insects and molecular basis of nematode transmission of viruses.

Block 3- Novel concepts in the management of plant parasitic nematode

Unit 1: Nematodes as model systems to study biologicalageing, nutrition, toxic environmental contaminations and cell motility.

Unit 2: Breeding for nematode race specific resistance through biotechnological and genetic engineering techniques.

Unit- 3: Novel concepts in nematode management –inhibition of steroid / hormone metabolism, exploring sensory stimuli, biological activity and mode of action of Avermectins. Modeling and computer simulations in integrated nematode management programmes**.**

Practical

Mechanism and genetic basis of plant resistance. Breeding for nematode race specific resistance through biotechnological and genetic engineering techniques-recombinant DNA (gene silencing); somatic hybridization and protoplast fusion. Novel concepts in nematode management –inhibition of steroid/hormone metabolism, exploring sensory stimuli, biological activity and mode of action of Avermectins. Identification of indigenous bio-control agents, their mass production and distribution. Modelling and computer simulations in integrated pest management programmes. Internet tools and application in Nematology.

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- ROLAND N. PERRY. AND MAURICE MOENS, 2006, Plant Nematology. CABI Press, 565 pp.
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PAT 608 SEED PATHOLOGY (1+1)

Objectives

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/loses and management.

Theory

Block 1: History and economic importance

Unit 1: History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO.

Unit 2: Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

Block 2: Disease development in seed and seedling

Unit 1: Recent advances in the establishment and subsequent cause of disease development in seed and seedling.

Unit 2: Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

Unit 3: Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens.

Block 3: Epidemiological factors

Unit 1: Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics thought seed borne infection.

Unit 2: Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health.

Unit 3: Management of seed-borne pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism.

Practical

Collection of seed samples and testing for seed borne diseases. Examination of dry seeds, NAOH seed soak method, Blotter method, seedling symptom test, Agar plate method, seed floatation, Grow on test (For bacteria), Indicator plant test for viruses, Seed to plant transmission. Serological method of seed testing, Test tube agar method and DNA based seed borne pathogen detection and electron micrograph identification.

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Ph.D. in Plant Physiology

Course Code	Course Title	Credit Hours
PPH 601	Functional Genomics and Genes Associated with a Few Physiological Processes	2 (2+0)
PPH 602	Signal Perceptions and Transduction and Regulation of Physiological Processes	2 (2+0)
PPH 603	Molecular Approaches for Improving Physiological Mechanisms Through Trait Introgression	3 (2+1)
PPH 604	Plant Phenomics–Next Generation Phenomics Platforms	2 (2+0)
PPH 605	Experimental Techniques to Characterize Plant Processes for Crop Improvement	2 (0+2)
PPH 606	Global Climate Change and Crop Response	2 (2+0)
PPH 607	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3 (3+0)
PPH 608	Seed and Fruit Growth and their Quality Improvement	2 (2+0)
PPH 609	Plant-microbe Interactions	3 (2+1)
PPH 610	Weed Biology and Physiology of Herbicide Action	2 (2+0)
	Total	**23 (19+4)**
PPH 680	Qualifying Examination	3 (0+3)
PPH 681	Seminar -I	1 (0+1)
PPH 682	Seminar - II	1 (0+1)
PPH 683	Teaching Assistantship -I	1 (0+1)
PPH 684	Teaching Assistantship - II	1 (0+1)
PPH 691	Research -I	18 (0+18)
PPH 692	Research -II	18 (0+18)
PPH 693	Research -III	18 (0+18)
PPH 694	Research -IV	18 (0+18)

PPH 601 FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES (2+0)

Objectives

Agriculture in India face stremendous challenges on multiple fronts. There is a need for targeted improvement of crops to meet the increasing food demand. Thorough understanding of the plant physiological processes, pathways and genes associated with the path way sareneeded for speed breeding and trait improvement.With help of modern tools and techniques, in the genomic ear, a large amount of data on genomic resources has been developed. The post-genomic era concentrateson assigning functions to the every gene identified in plants. The PhD scholar working on plant biology and related field must be exposed to recent trends and developments in this new emerging area. The major emphasis would be on new development singenomics to regulate plant growth.

Aim of the course

The major goa listoe xpose the students of higher education program on functional genomic approaches, which is needed for crop improvement in a targeted way:

(i) Identify genes regulating the specific mechanisms / traits.

(ii) Assess the relevance of physiological processes / mechanisms and options to combine / introgress them.

The course is organized as follows:

No.	Blocks		Units
1.	Functional Genomics and Genes: Physiological Processes	1. 2. 3. 4. 5. 6. 7.	Gene Discovery Genetic Tools for Plant Development Gene Knock Out Approaches Chemical Genomics Gene Over Expression Approaches Synthetic Biology and Interaction Studies Case Studies

Theory

Block 1: Functional Genomics And Genes: Physiological Processes

Unit 1: Gene Discovery

Finding genes in complex plant system, Constructing gene-enriched plant genomic libraries, Recent advancements in genome sequencing, RNA sequencing and expression, In Silico prediction of plant gene function, Quantitative Trait Locus analysis as a gene discovery tool, Gene expression analysis –micro-array and deep.

Unit 2: Genetic Tools for Plant Development

Understanding the importance of mutants in unrevealing the physiological processes, genome wide insertional mutagenesis – T-DNA insertion mutants, Gain in function, Transposon mutagens, Transposition, Physical and Chemical mutagenesis, Gene and Enhancer Traps for Gene Discovery, High-Throughput TAIL-PCR as a Tool to identify DNA Flanking insertions, High-Throughput TILLING for functional Genomics, Genome editing approaches for functional analysis of genes.

Unit 3: Gene Knock Out Approaches

PTGS-Antisense technology, Virus induced gene silencing (VIGS), Custom Knock- outs with Haripin RNA-mediated Gene Silencing and other silencing tools, Complementation studies.

Unit 4: Chemical Genomics

Reverse chemical genomic approaches for functional validation of genes, Protein structure prediction, homology modelling and virtual screening by using bioinformatic approaches to identify the small molecules and their validation through phenotyping assessment.

Unit 5: Gene Over Expression Approaches

Vector Construction for Gene Overexpression as a Tool to Elucidate Gene Function Transient expression, Transgenics, Targeted and conditional expression of transgene. Multiple gene expression by Nanostring technology, Co-expression analysis and gene networking to identify potential genes in the pathway (informatics), Epigenetics.

Unit 6: Synthetic Biology and Interaction Studies

Engineering microbial pathways in plants (eg, photosynthesis), DNA-protein & Protein-protein interaction studies, yeast hybrid system, Correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome, Multivariate analysis and identification of metabolite as biomarkers.

Unit 7: Case Studies

Functional characterization of genes associated with important cellular processes influencing crop growth and development: genes controlling photosynthesis and nutrient uptake, Functional characterization of genes associated with important cellular processes influencing crop growth and development: genes controlling respiration and photorespiration, Functional characterization of genes associated with important cellular processes influencing crop growth and development: fatty acid biosynthesis, seed protein quality and quantity, Functional characterization of genes associated with important cellular processes influencing crop growth and development: genes controlling flowering.

Teaching methods/activities

- Lecture
- Assignment(Reading/Writing)
- Student presentation

Learning outcome

After successful completion of this course students are expected to have in depth knowledge on the genetic tools for plant development.

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PPH 602 SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES (2+0)

Objectives

Bio signaling is emerging as an import fields in plantbiology. Thorough understanding of signal perception, activation and cellular changes associated is needed for manipulation of specific traitsor events in plants. The M.Sc. PhD scholar working on plant biology and related field must be exposed to this new emerging area. Plant response to external and internal factors is mainly through signal perception and amplification leading gene expression which brings in altered metabolism regulating physiological and biochemical processes and finally plant processes and growth. The course provides in sights on the diverse receptors, lig and receptor interaction and the role of secondary messengers in signal amplification leading to gene expression and finally regulating plant growth.

Aim of the course

Objective of this course is to provide comprehensive exposure on different signaling events and associated cellular changes in plants. The course will include lectures on the signaling mechanisms employed by plants to perceive and transducer environmental signals.

The course is organized as follows:

No.	Blocks		Units
1.	Signal Perceptions and Transduction: Regulation of Physiological Processes	1.	Concept of Receptor and Ligands
		2.	Receptors – Signal Perception and Transfer
		3.	Hormone Signaling
		4.	Light Signaling
		5.	Abiotic Stress Signaling and Nutrient Signalling
		6.	Signaling Cascade during Developmental Events
		7.	Signal Perception and Transduction in Plant Defense

Theory

Block 1: Signal Perceptions and Transduction: Regulation of Physiological Processes

Unit 1: Concept of Receptor and Ligands

Signal, signal types, long (diffusible) and short (contact) range signaling and components of signaling. Types of receptors, nature of ligands, downstream components like primary, secondary signaling components.

Unit 2: Receptors – Signal Perception and Transfer

Cell surface trans-membrane receptors- GPCRs, Receptor Tyrosine Kinases (RTKs), Receptors Serine Threonine kinases (RSTKs), Receptor-Like Kinases (RLKs), receptor two component systems. Signal transfer phosphor-relay and generation of secondary signaling components and activation of TFs or enzymes. Downstream components- G-proteins, second messengers-Cyclic AMP, Adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-kinases; effector molecules (transcription factor).

Unit 3: Hormone Signaling

Hormone binding receptors-Transduction process. Effector molecules and gene expression. Specific signaling pathways of Auxins, Cytokinin, Gibberellins, Ethylene, ABA, Brassinosteroids, Salicylic Acid, Strigolactone, polyamines, Jasmonic acid, etc. which leads to formative effects. Cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

Unit 4: Light Signaling

Perception of light-pigments involved-activation of phytochrome/ cryptochrome (study of mutants). Light signal transduction. Multiple signaling cascades- identification of signaling components through mutant analysis-changes in gene expression.

Unit 5: Abiotic Stress Signaling and Nutrient Signaling

Sensing of environmental factors (Temperature-Osmotic-Ionic stress), Activation of specific molecules and secondary messengers, activation of downstream components-leading to stress gene expression, Case studies with different abiotic stresses, Retrograde signaling, Nitrogen fixation, nitrogen and phosphorus uptake, nutrient translocation.

Unit 6: Signaling Cascade during Developmental Events

Leaf senescence/fruit development and ripening, Tuberization, Sugar signaling. Signaling during seed germination.

Unit 7: Signal Perception and Transduction in Plant Defense Responses General mechanisms to pathogen response, Role of salicylic acid and active oxygen species, Cross Talk Signaling- Stress matrix under field conditions, cross talkbetween abiotic-abiotic stress, biotic-abiotic stress signaling networks.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Learning outcome

By the end of this course, the student will be able to:

1. Comprehend various signalling events and associated physiological changes in plants.
2. Understand the diverse roles of receptors, lig and receptor interaction and the role of secondary messengers in signal amplification leading to gene expression.

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PPH 603 MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL MECHANISMS THROUGH TRAIT INTROGRESSION (2+1)

Objectives

Phenomenal progress in understanding the basic physiological mechanisms that determine crop performance has been made in recent years. Extensive deciphering of the molecular and genetic basis of variations in these mechanisms has led to the enumeration of several “physiological traits” that have enormous relevance to improve yield potentials as well as adaptation to various biotic and abiotic stresses. Although most of the physiological traits have been considered as complex and hard to breed, recent advances in understanding the sub-components of most of the major mechanisms coupled with the progress made in “phenotyping” to capture genetic variability in such sub component traits have paved way for the adoption of “trait based breeding” approaches. The tremendous progresses made in genomics have also led to the development of extensive molecular and genetic resources that can be used for a focused “breeding by design”.

Aim of the course

Deep understanding of modern translational research methods such as molecular breeding, transgenics, geno meediting, grafting and reverse breeding approaches such as Double dhaploidization will be provided to the students. Contemporary developments in molecular approaches in accelerated crop improvement would bedealt with. Acquainting with the approaches and techniques is crucial for young students to groom themselves into focused and successful scientists in future. Theoretical and practical concepts of trait introgression (ortraitpy ramiding) will be discussed in this course so as to provide recent developments in this area of research. To acquaint with regulatory aspects of working with transgenic plants iscrucial and will be discussed elaborately.

The course is organized as follows:

No.	Blocks		Units
1.	Trait Introgression through Molecular Breeding	1.	Physiological Traits Relevant for Crop Improvement and their Phenotyping
		2.	Identification of QTL by Bi-parental Mapping Approach
		3.	Identification of QTLs by Association Mapping Approach
		4.	Trait Introgression by Molecular Breeding
2.	Trait Introgression through Transgenic Technology	1.	Gene Discovery and Gene Constructs for Relevant Plant Traits/Adaptive Mechanisms
		2.	Trait Improvement or Pyramiding through Transgenic Technology
		3.	Genome Editing, a Potential Option for Gene Regulation by Transgenic Approach
		4.	Characterization of Transformed Plants and Event Selection Strategies
3.	Other Approaches for Trait Introgression	1.	Trait Introgression through Tissue Grafting and Asexual Propagation
		2.	Doubled haploids for Trait Introgression

Theory

Block 1: Trait Introgression through Molecular Breeding

Unit 1: Physiological Traits Relevant for Crop Improvement and their Phenotyping

Physiological traits with relevance to growth, development, biotic/ abiotic stress tolerance, nutrient acquisition, Concept of complex, multi-gene control of physiological traits, Concepts of trait introgression to augment crop productivity and/or stress adaptation.

Unit 2: Identification of QTL by Bi-parental Mapping Approach

Concepts of developing trait-specific mapping population and identification of contrasting parental lines through phenotyping, Mapping populations and their developments – F2, RIL, doubled haploid populations, Accurate phenotyping of bi- parental mapping populations, Conventional Genotyping strategies using SNP andSSR markers, other rapid approaches like GBS, RADseq, QTLseq etc., Composite interval mapping and other approaches for QTL discovery.

Unit 3: Identification of QTLs by Association Mapping Approach

Concepts of assembling a "Panel" of germplasm amenable for association mapping based on molecular and phenotypic diversity, Concepts of linkage disequilibrium, LD decay and population structure, Concepts QTL discovery in structured populations. Phenotyping of the association mapping populations, Concepts of Genome wide association studies (GWAS).

Unit 4: Trait Introgression by Molecular Breeding Approaches

Strategies for QTL introgression and Marker Assisted Selection (MAS), Various breeding methods for trait introgression: Marker assisted backcross breeding (MABC), Marker assisted recurrent selection (MARS), Marker assisted phenotypic selection (MAPS), etc.

Block 2: Trait Introgression through Transgenic Technology

Unit 1: Gene Discovery and Gene Constructs for Relevant Plant Traits/ Adaptive Mechanisms

Map-based cloning to identify novel genes and their allelic variants, Identification of differentially expressed genes through transcriptome, metabolome and proteome analysis in contrasting genotypes, Gene identification through forward (inducing mutations with radiation, chemicals, or insertional mutagenesis)and reverse genetic approaches (site-directed mutagenesis, gene knockout or knockdown), Cloning full-length candidate genes, inducible promoters, Concepts of "codon optimization" to make constructs for specific crops.

Unit 2: Trait Improvement or Pyramiding through Transgenic Technology

Introduction to GMOs and its application in crop improvement, Gene stacking strategies for trait improvement, *Agrobacterium* and other methods of plant transformation including gene gun, *in planta*, etc.

Unit 3: Genome Editing, a Potential Option for Gene Regulation by Transgenic Approach

Genome editing techniques: CRISPR/Cas9, Zinc finger nucleases, etc, CRISPR as tool to generate loss-of-function and gain-of-function transgenics.

Unit 4: Characterization of Transformed Plants and Event Selection Strategies

Molecular analysis bySouthern, qRT-PCR/Northern analysis, and immunoassays, Concepts of copy number and desirable number of independent events, Evaluation of transgenics based on empirical/ physiological/biochemical processes under specific conditions – containment and confined field trials, Generation of T1 populations, event characterization, Molecular data as per regulatory requirements, Biosafety and Regulatory aspects of GMO.

Block 3: Other Approaches for Trait Introgression

Unit 1: Trait Introgression through Tissue Grafting and Asexual Propagation

Concept of identifying root stocks with superior traits, grafting, scion root stock interaction, compatibility, concept of chimeric grafting in transgenic technology involving a non-transgenic shoot to a transgenic root.

Unit 2: Doubled haploids for Trait Introgression

Concept of crossing trait donor lines and developing doubled haploids from the F1 anthers, Screening and identifying trait introgressed doubled haploids.

Practicals

- Phenotyping approaches for the different physiological traits. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping options for SSR markers using capillary and chip based fragment analysis systems. scoring of gels and assessment of polymorphism
- Statistical approaches to assess genetic variability, heritability and other parameters. Phylogenetic analysis and principle component analysis and construction of dendrograms. Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs.
- Bioinformatics – sequence analysis, structure analysis, designing primers for SSR regions, SNP2CAPS approaches of genotyping.
- Molecular biology - genomic/plasmid DNA isolation, RNA isolation. Full-length gene cloning, vector construction with specific promoter, gene stacking and transient assays. Transformation in model system
- Crop transformation - *Agrobacterium* mediated transformation (in-planta and invitro), particle-gun transformation.
- Evaluation of transgenics – semiquantitative and quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene and testing LOD.
- Improvement of traits based on grafting options.
- Techniques in developing doubled haploids and characterization.

Teaching methods / activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

– Practicals

Learning outcome

By the end of this course, the student will be able to:

1. Comprehend the basic concepts of modern translational research methods such as molecular breeding, transgenics, genome editing, grafting etc.
2. Describe reverse breeding approaches such as double dhaploidization
3. Accumulate both the oretical and practical concepts of trait introgression

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PPH 604 PLANT PHENOMICS-NEXT GENERATION PHENOMICS PLATFORMS (2+0)

Objectives

Crop improvement in the present scenario is increasing focusing on trait-based breeding. The phenomenal progress made in genomics cannot be exploited for improving plant traits/mechanisms unless phenotyping technologies are developed to capture genetic variability. Several technologies have been developed to accurately quantify genetic variability in specific traits.

Aim of the course

The course aims at providing cutting edge knowledge on the current progress made in various phenol typing techniques and approaches. The students will beversed with principles of various phenol typing approaches. The aim is to provide hands-on expertise in analyzing trait diversity. Exposure will be provided on Non-invasive imaging technologies that drive the phenomics platforms. The course provides comprehensive exposure on recent developments in phenomics platforms imaging tools/techniques and recent trends in designing specific phenomics platforms e.g., drought studies/root phenol typing etc.

The course is organized as follows:

No.	Blocks		Units
1.	Concepts of High throughput Phenotyping and its Requirement	1.	Concepts of Phenotyping
		2.	Physio-Morphological Traits Associated with Crop Performance
		3.	Features of Phenomic Platforms
		4.	Trends in Phenomics
		5.	Non-invasive Phenotyping Approaches
2.	Applications of the PhenomicsPlatforms	1.	Basic Studies to Assess the Crop Response
		2.	Applied Studies Focused on CropImprovement Programs

Theory

Block 1: Concepts of High throughput Phenotyping and its Requirement

Unit 1: Concepts of Phenotyping

The concepts of “phene and trait” analogous to gene and allele. Genome-phenome relationship, definition of phenotyping, GxE interaction on phenome.

Unit 2: Physio-Morphological Traits Associated with Crop Performance Overview of phenotyping needs to complement genomic resources, specific traits associated with yield potential, stress adaptation (both biotic and abiotic stresses).Need for high throughput precision phenotyping approaches for basic studies andto generate genetic and genomic resources.

Unit 3: Features of Phenomic Platforms

Precision growth conditions, maintenance of light, temperature/ VPD and RH to realize the potential crop growth response, Controlled environmental facilities for simulating challenging climatic conditions to phenotype diverse plant traits, Concept of sensors, diverse sensors and their utility in precise quantification of environmental variables, soil moisture sensors, Imaging to capture plant traits, image acquisition. Automated big data access, processing, etc.

Unit 4: Trends in Phenomics

Types of phenomic platforms- Laboratory, Greenhouse and the field-based platforms. Platforms designed for specific needs i.e., root phenotyping, drought studies etc., Crop specific phenotyping, mobile and stationary platforms, Global trends in establishing major phenomics platforms, and their characteristic features and impact.

Unit 5: Non-invasive Phenotyping Approaches

The concept of non-invasive capturing of plant growth and health, Imaging technologies - image acquisition, segmentation and data analysis, Critical aspects of Visual, IR Thermal, Fluorescence, NIR, Hyperspectral imaging, Development and validation of models for deriving relevant physiological traits from image phenome. Concepts of Plants to sensors and sensors to plants, Stationary and ground based tractor mounted sensors/imaging tools, Unmanned aerial vehicle (UAV) sensors, Machine learning and its integration to analyze ground and aerial based images.

Block 2: Applications of the Phenomics Platforms

Unit 1: Basic Studies to Assess the Crop Response Functional validation of genes, chemicals and other interventions, Characterize the growth and stress response in contrasts to identify the relevance of adaptive trait.

Unit 2: Applied Studies Focused on Crop Improvement Programs Characterizing the pre-released promising lines for productivity under defined environmental variables. Phenotyping germplasm accessions, mapping populations for specific traits for mapping, Concept of Phenome Wide Association Studies (PWAS). Genomic selection, gene-based crop models to predict complex traits, Impact of phenomics platform, progress made, case studies.

Teaching methods/activities

- Lecture
- Assignment (Reading / Writing)
- Student presentation

Learning outcome

By the end of this course, the student will be able to understand the current progress made in various phenotyping techniques and approaches.

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PPH 605 EXPERIMENTAL TECHNIQUES TO CHARACTERIZE PLANT PROCESSES FOR CROP IMPROVEMENT (0+2)

Objectives

Technique, tools and instrumentation facilities drive the research in modern biology. The course addresses recent developments related to advanced methods based on novel methodologies and instruments. Besides the emphasis is on new emerging trends in assessing physiological and biochemical processes based on surrogate methods. Several molecular biology techniques are now essential to comprehend physiological processes. The course provide comprehensive picture on the seare as addressing recent developments in this area.

Aim of the course

Aim of this course is to provide exposure to phenotype very specific physiological processes which have direct relevance in crop improvement programmes. The course provides insight on recent techniques and methodologies on each of the major physiological processes like stress responses, photosynthetic process, hormone area, photo-morphogenesis and genomics aspects.

The course is organized as follows:

No.	Blocks		Units
1.	Characterization of Plant Processes:Experimental Techniques and Crop Improvement	1. 2. 3. 4. 5. 6.	Stress Responses Photosynthetic processes Hormonal Response on Specific Plant Growth Processes and Quantification Nutrient Response Acquisition and Quantification Photo and Thermo Morphogenesis Recent Approaches for Functional Genomics

Block 1: Characterization of Plant Processes: Experimental Techniques and Crop Improvement

Unit 1: Stress Responses

Thermal (reflectance) characters as a measure of water status and root characteristics, Oxidative stress induction and assessing the response on lipid peroxidation and quantification of ROS, RCC's, RNS, Fluorescence to assess the stress response, Water use efficiency quantification at leaf, plant level, surrogates for WUE, Tissue localization of ROS, RNS by qualitative staining and fluorescence- based methods.

Unit 2: Photosynthetic processes

Concept and approaches to assess of radiation utilization efficiency (RUE), Quantification of mesophyll and other diffusive resistances regulating photosynthesis. Carboxylation efficiency (light and CO2 response curves), RuBiSCO activation status.

Unit 3: Hormonal Response on Specific Plant Growth Processes and Quantification

Bioassays to assess the biological process regulated by hormones – new in-vivo assays, Promoter assays for hormone response- GUS/ YFP/GFP based assays- expression of hormone responsive genes, Recent analytical tools and techniques to quantify hormones – GC-MS, LC-MS, Capillary electrophoresis.

Unit 4: Nutrient Response Acquisition and Quantification

Recent advances in soil less cultures to study the nutrient response- Hydroponics/Ray Diffraction analysis) and hyper spectral reflectance.

Unit 5: Photo and Thermo Morphogenesis

Photo receptors, light and temperature regulation of plant growth and flowering, Thermal time, heat units, GDD, Concept and approaches for speed breeding.

Unit 6: Recent Approaches for Functional Genomics

In silico prediction of gene function, Flanking sequence identification in insertional (T-DNA/transposon) mutants, Concept of insertional mutagenesis and mutant experiments, Utilization of genetic resources for functional genomics – mutants and tilling, eco tilling, VIGS, RNAi, miRNA, Genome editing –CRISPR, Concept of chemical genomics for functional validation, Relevant molecular tools to assess gene expression or (to regulate the process and assign a function to gene), Multiple gene expression by Nano String technology, Cap analysis gene expression (CAGE)– to identify start point of transcription, Yeast hybrid interaction, Immunoprecipitation, Chip-PCR.

Teaching methods / activities

- Practical Assignments
- Results presentation

Learning outcome

After completion of this course students are expected to develop practical skill and knowledge on various experimental techniques employed in crop improvement programme. Moreover, students will have experience with characterization of plant processes.

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PPH 606 GLOBAL CLIMATE CHANGE AND CROP RESPONSE (2+0)

Objectives

Present Indian agriculture encounters tremendous challenges due to rapid climate change. Climate echange exerts remarkable negative impact on food, nutritional and ecological security. It significantly affects the plant physiological processes, hence yield is severely affected. Therefore students of plant physiology need to quip themselves with knowledge and skill sets required to navigate the climate change scenario and its impact on crops physiological processes. Hence, this course is designed.

Aim of the Course

The course is designed to provide basic knowledge on the subjects of crop responses to climate change. The aim of this course is to address both long-term and short-term effects of climate change on crops, natural vegetations and eco systems.

No.	Blocks		Units
1.	Climate Change: Crop Response and Mitigation	1.	Fundamentals of Climate Change
		2.	Manifestations of Climate Change
		3.	Major GHGs (CO_2, Methane, NO_2 etc.), their Production Rates, Monitoring and their Influence on Climate Change
		4.	Agricultural Practices on GHG Production
		5.	Direct and Indirect Effects of Climate Change on Plant Processes
		6.	Climate Change Scenario and Impact on Crops
		7.	Ozone Depletion leading to Increased Ionizing Radiations and its Implications on Crop Growth
		8.	Long-term and Short-term Projections of Climate Change: Effects on Natural Vegetation and Ecosystems
		9.	Technologies for Climate Change Mitigation in Agriculture
		10.	Climate-resilient Agriculture
		11.	Climate Change: Technologies for Crop response studies
		12.	Politics of Climate Change Negotiations

Theory

Block 1: Climate Change: Crop Response and Mitigation

Unit 1: Fundamentals of Climate Change

Definition of climate change, history and evidences of climate change and its implications. Natural and anthropogenic climate change. Sources of Greenhouse Gas (GHG) emission, Global Warming Potential of GHGs, accumulation of GHGs in the atmosphere and science behind climate change, industrial revolution and GHG build-up in the atmosphere, Energy-Emission-Economy Interactions, carbon intensity of economy, carbon equity/justice.

Unit 2: Manifestations of Climate Change

Impact on monsoons, occurrence of extreme weather events, hydrological cycle and water availability, effect on crop growing period in tropics, subtropics and temperate regions, shifts in distribution of flora and fauna, effects on biodiversity and migration of tropical plant species to higher latitudes and altitudes.

Unit 3: Major GHGs (CO2, Methane, NO2, etc.), their Production Rates, Monitoring and their Influence on Climate Change

GHGs: An Overview, - role of CO2, methane and major uncertainties. Mechanism of their production and emission from various, source and sinks of GHGs; and contribution of GHGs to global warming. Techniques used in monitoring GHGs.

Unit 4: Agricultural Practices on GHG Production

Carbon footprint analysis of agriculture and various agricultural practices contribute to climate change. Impacts of natural factors and farming practices on greenhouseenteric fermentation, manure management, other sources. Opportunities to reduce GHG emission from Agriculture.

Unit 5: Direct and Indirect Effects of Climate Change on Plant Processes Problems and Prospects of Crops with changing temperature: Growth and Development of Crop plants, Thermo-morphogenesis, phenology, Physiologicalprocesses such as photosynthesis, Net carbon assimilation, C3 and C4 plants adaptation,Respiration, Nutrient acquisition and metabolisms, Plant water relationsand Heat shock proteins, Grain/seed development: Grain Quality parameters and yield.

Unit 6: Climate Change Scenario and Impact on Crops

Different scenarios for temperature, rainfall in different agro-climatic zones of India and their impact on crop growth and productivity. Major climate change (temperature, CO2, and rainfall) impact quantification using field or controlled environment experiments, meta-analysis and simulation models. Some examples of crop simulation models calibration and their application in short-term and long-term predictions.

Unit 7: Ozone Depletion leading to Increased Ionizing Radiations and its Implications on Crop Growth

Role of CFCs in ozone depletion, penetration of ionizing UV radiations and its implications on crop growth.

Unit 8: Long-term and Short-term Projections of Climate Change: Effects on Natural Vegetation and Ecosystems

Response of natural ecosystems to increasingatmospheric CO2 concentration and climate warming, effect of climate change on quality of feed i.e leaf and stored grains/seeds, its implications on pollinators and pests.

Unit 9: Technologies for Climate Change Mitigation in Agriculture Agricultural biotechnology to produce crop varieties with enhanced carbon uptake. Nutrient management: Management of nitrogenous fertilizers. Tillage/residue management: 1.Conservation tillage CO2 mitigation technology; 2. Biochar: A potentialtechnique for carbon sequestration.Methane mitigation using reduced tillage technology, change in methanogenic bacterial activity using electron acceptors.Carbon sequestration potential, concept and measurement.

Unit 10: Climate-resilient Agriculture

Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments.

Unit 11: Climate Change: Technologies for Crop response studies Temperature Gradient Chambers, Temperature Gradient Greenhouses, Soil plant atmosphere research system (SPAR), Infra-red warming Technology, Free Airtemperature enrichment technology, Soil Warming system etc.

Unit 12: Politics of Climate Change Negotiations

IPCC, Major International conventions/treaties, Kyoto Protocol, Paris Agreement, Global initiatives on Carbon sequestration, carbon trading.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Learning outcome: After completion this course, students will be able to obtain indepth and basis knowledge on crop responses to climate change.

Suggested Reading

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- MoEF and CC website
- National Communication toUNFCCC

PPH 607 PHYSIOLOGICAL AND MOLECULAR ASPECTS OF SOURCE-SINK CAPACITY FOR ENHANCING YIELD (3+0)

Objectives

Yield level reached plateau in many crops improving yield potential and crop grow thrate forms the basis for further improvement in productivity. Photosynthesis and the establishing sink capacity are crucial processes to achieve this goal. Verygood progress has been made in deciphering the molecular mechanisms to regulateseveral photosynthetic processes at cellular and canopy level. Similar insights nowexist regarding establishing sink size (capacity). In the last five years, phenomenalconceptual approaches have been developed to understand the basic physiological and molecular mechanisms to enhance the source through photo synthetic processes. Besides, scientific insights in recent years provided leads in improving sinkie., yield associated traits.Yield plateau can be broken only by enhancing yield potential by structured improvement in source capacity and sink size.

Aim of the course

The course addresses the recent development in photo synthetic processes that can be exploited to improve yield potential. Besides, other major emphasis is to provide exposure on recent developments in regulating the sink characters ie., yield attributes at molecular level to achieve higher potential yields.

Thecourseisorganizedasfollows:

No.	Blocks		Units
1.	Source Size and Function-Basic Concepts, Physiological and Molecular Mechanisms, Genomic RESOURCES to Regulate Source Characters	1. 2. 3. 4. 5.	Source Establishment Source Function- Photochemical Reactions Source Function- CO2 Diffusion and Concentration Source Function- Metabolic Engineering of CO2 Fixation Case Studies to Improve Source Capacity
2.	Improving Sink Size and Capacity	1. 2. 3. 4.	Sink Establishment Increase the Sink Size by Enhancing the Relevant Constituent Traits Genetic Genomic RESOURCES, Genes/QTLs,Genetic RESOURCES to Improve SinkTraits– Case Studies Source to Support the Sink Capacity

Theory

Block 1: Source Size and Function–Basic Concepts, Physiological and Molecular Mechanisms, Genomic Resources to Regulate Source Characters

Unit 1: Source Establishment

Maximize energy capture by improved light interception, light distribution and itsincrease, Increase canopy size by vertical expansion

– concept of increasing optimum LAI levels, Concepts of semi-tall varieties with resistance to lodging: traits associated with lodging resistance, Sustain net carbon gain with age – the relevance of stay green character, photon capture and achieve high CO2 reduction to photon ratiounder low light, Options for increasing canopy photosynthesis, Relevance ofmaintaining cell turgor and nutrient status.

Unit 2: Source Function- Photochemical Reactions

Maximize conversion efficiency of intercepted radiation by improving net carbon gain - Emerging solutions to increase carbon fixation rate, Improve efficiency of photochemical reaction by - Engineering the pigments to expand PAR spectrum into IR range; reduce antenna size, optimize energy dissipation mechanisms; optimize components of ETC and downstream acceptors; accelerate adaptation for shifting light intensities.

Unit 3: Source Function- CO2 Diffusion and Concentration

Enhance stomatal conductance (gs) and mesophyll conductance (gm) – guard cell metabolism; concepts of leaf mesophyll tissue thickness (SLW), Concepts of VPD responses of gs to enhance duration of photosynthesis during the day, Bicarbonate transports and aquaporins; achieve higher CCM - Engineering C4 cycle, CAM, cyanobacteria, carboxysomes, algal pyrenoids.

Unit 4: Source Function- Metabolic Engineering of CO2 Fixation

RuBisCO carbon fixation activity - Increase and optimize kinetics of RuBisCO with enhanced specificity to CO2, Engineer RuBisCO to minimize feedback regulation by metabolite inhibitors, Increased activation state by improving stability andfunction of RuBisCOactivase; optimize RuBp regeneration – modulate specific enzyme levels. New concepts on photorespiratory synthetic bypass.

Unit 5: Case Studies to Improve Source Capacity

Genetic and genomic resources, genes/QTLs associated with specific yield potential traits and/or photosynthetic mechanisms, Genetic resources to improve source traits- case studies.

Block 2: Improving Sink Size and Capacity

Unit 1: Sink Establishment

Optimise duration of phenological stages related to sink establishment, genetic and environmental factors, GDD and phenology.

Unit 2: Increase the Sink Size by Enhancing the Relevant Constituent Traits

Role of hormones in regulating molecular mechanisms of yield structure development, Genomic and genetic resources developed for regulation/improvement of such traits. – Sink Size: Tillering associated traits, branching patterns/fruiting points, spikelet number, pod number, fruit number. – Sink development: Basic concepts and molecular mechanisms associated with pollination, fertilization, ovary development in determining the spikelet fertility/sterility components and strategies for engineering seed/fruit size in crop plants.

Unit 3: Genetic and Genomic Resources, Genes/ QTLs, Genetic Resources to Improve

Sink Traits- Case Studies. Progress and status in developing genomic and genetic resources of validated genes/ QTLs to improve sink traits- Specific case studies.

Unit 4: Source to Support the Sink Capacity

Canopy architecture to support sink requirements in cereals: plant height, tillering, leaf area, shading or senescence of lower canopy leaves, canopy photosynthesis, Canopy architecture to support sink requirements in Pulses: Leaf senescence, abscission, mobilization of N and other nutrients, Symbiotic N fixation to support sink size and

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Studentpresentation

Learning outcome

By the end of this course, the student will be able to:

1. Comprehend the current development in photo synthetic research
2. Knowhow to employ the theoretical concept to photo synthetic research in yield improvement programme
3. Understand themechanisms of source and sink establishment

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PPH 608 SEED AND FRUIT GROWTH AND THEIR QUALITY IMPROVEMENT (2+0)

Objectives

Seedas a propagule is an important input for agriculture. From this context,

As pects related to seed development, its dormancy and viability etc. assumes significance. Besides, seed is the major source of nutrition to mankind and hence, quantitative and qualitative differences in seed constituents and their modificationand improvement have been the area of focus in recent years. Several molecularapproaches are now being adapted to improve the seed characters like longevity, vigour and seed quality. In addition to seed and fruit development, processes regulating the post-harvest deterioration of fruits and vegetables, increasing theirself-life are another area that needs comprehensive intervention involving molecular biology tools and techniques. The course therefore addresses recent developments on the seaspects.

Aim of the course

The major aim of the course is to train and educate the students about the importance of seeds and fruits as a source of nutrition for human health. Further,this course also addresses how to improve the nutritional status besides protecting the nutritive value of seeds and fruits. Inaddition, the other aim of the course is to address to regulate the post harvest deteriorationof seeds and fruits to minimize the losses.

No.	Blocks		Units
1.	Physiological and Molecular Aspects of Seed and Fruit Growth: Quality Improvement	1.	Physiology of Seed Growth and Development
		2.	Seed as a Propagule
		3.	Seed as a Source of Nutrition
		4.	Quality Deterioration during Storage
		5.	Fruit Growth and Development
		6.	Fruit as a Source of Phytochemicals: Nutraceuticals
		7.	Fruit Ripening, Post Harvest Deterioration and Shelf life

Theory

Block 1: Physiological and Molecular Aspects of Seed and Fruit Growth: Quality Improvement

Unit 1: Physiology of Seed Growth and Development

Mechanism of seed development and different developmental stages; synthesis, mobilization and accumulation of stored reserves, Forms of stored reserves and their localization, Sink drawing ability (SDA) and its relevance in seed growth and development, Role of plant hormones in seed growth and development and SDA.

Unit 2: Seed as a Propagule

Seed as a propagation material; seed size and seed chemical composition and their relevance in seed germination, Physiological, biochemical and molecular mechanisms and approaches to regulate seed germination, seedling emergence and establishment and seedling vigour, Physiological, biochemical and molecular mechanisms and approaches to regulate seed priming and crop establishment: seed dormancy, precocious germination and controlling pre-harvest sprouting in crops, Physiological, biochemical and molecular mechanisms and approaches to regulate seed viability, improving the viability and storability of seeds.

Unit 3: Seed as a Source of Nutrition

Seed as a source of nutrition to humans: approaches to improve the quality of seeds through synthesis of seed storage reserves and other constituents, Genes/ QTL's regulating these processes and concept of pathway engineering to improve the quantity and quality of seed constituents, Carbohydrates- Amylose and amylopectin ratios for glycemic index, resistant and digestable starch, improving dietary fibre, alter gelatinisation, Protein content, modified proteins, essential amino acids, Oil content, fatty acid composition, Omega 3 fatty acids. Carotenoids and vitamins, Biofortification strategies to enhance the grain zinc, iron, other minerals and other essential compounds, Engineering for low protease inhibitors, phytic acid, tannins, phenolic substances, lectins, oxalates as anti-nutritional factors, Case studies of improving seed nutrition components by molecular breeding and transgenic approaches.

Unit 4: Quality Deterioration during Storage

Changes in chemical composition during storage; factors influencing the deterioration of nutritional quality of seeds during storage; approaches to minimize nutritional quality deterioration, Effect of quality deterioration on human and animal health

Unit 5: Fruit Growth and Development

Flower and fruit development; concept of parthenocarpy, Physiological and biochemical changes during fruit development and chemical composition, Molecular approaches to regulate flower and fruit drop/ abscission; Role of hormones.

Unit 6: Fruit as a Source of Phytochemicals: Nutraceuticals

Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Antioxidants, Flavanoids, anthocyanins, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Vitamins- Vitamin C, Tocopherol, Carotenoids, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Alkaloids, Mangiferin, tomatins, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of DigestableFiber lycopene, stillbeans, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Aroma, monoterpenoids and Fatty acid esters.

Unit 7: Fruit Ripening, Post Harvest Deterioration and Shelf life Physiological and molecular mechanisms of fruit ripening, Postharvest deterioration of fruits; factors regulating fruit deterioration; hormonal and environmental aspectsof reducing post harvest deterioration of fruits, Physiological and Molecularapproaches to regulate fruit ripening and shelf life: Role of Ethylene and Ethylene response factors regulating specific processes of fruit ripening; Approaches to regulate specific shelf life characters, Improving fruit ripening and shelf life by molecular approaches-Case studies.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Learning outcome

After successful completion of this course, the students are expected to be able to:

1. comprehend the importanceof seeds andfruits as asource of nutrition
2. describe how to improve the nutritional status of grains and fruits
3. know how to protect the nutritive value of seeds and fruits
4. detect the postharvest deterioration of seeds and fruits and to minimize the losses

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PPH 609 PLANT-MICROBE INTERACTIONS (2+1)

Objectives

Plant micro been counters can be friendly or hostile. Plants are associated with a variety of microorganisms, including end ophytes, phylloplane and rhizosphere microbes which provide plants with mineral nutrients and other benefits. In contrast phytopathogens obtain nutrition from plants leading to reduction in plant growth and subsequent killing. Besides the genetic make up expression of the phenotype is regulated by environment and the plant micro beinteractione specially the endophytes. It is also relevant to understand the plant-pathogen and plant-insect interactions to improve to lerance mechanisms by altering specific physiological and biochemical processes. The combined effects of biotic and abiotic are another aspects of importance. Understanding how physiology of plants simultaneously exposed to abiotic stress and pathogens decides the outcome of their interaction sis important. The course provides comprehensive in formation on these aspects. Plant-micro beinteractionisan emerging area and PhD scholar must be exposed to this new knowledge which migh the lpinmanipulation plant traits and boost crop growth.

Aim of the Course

The objective of the course is to provide the understanding how beneficial microbes (endophyte/rhizosphere/phylloplanemicrobiome) playarole in boosting the plant immune system and there by stimulate plant health and growth.The course also aims to understand how plant pathogens are able to infect plants and how resistant plants are able to defend themselves.The course covers comprehensive interactive information from physiology, microbiology and genomics.

No.	Blocks		Units
1.	Plant Pathogen Interaction	1.	Introduction to Plant Pathogen Interaction
		2.	Genetic Basis of Host Pathogen Interaction
		3.	Growth Regulators of Plant Defense and Susceptibility
		4.	Bioenergetics in Plant Pathogen Interaction
2.	Plant-Endophytes/ Rhizosphere/Phylloplane Microbes Interaction	1.	Interaction of Endophytes/ Rhizosphere/ Phylloplane Microbes with Plants
		2.	Role of Endophyte/ Rhizospheric/ Phylloplane Microbiota in Plant Physiological Processes
		3.	Endophyte/ Rhizospheric/ Phylloplane Microbes in Improving Biotic and Abiotic Stress Tolerance
		4.	Bioethics, Biosafety, Intellectual property rights and implications in plant-microbe research
3.	Microbial Interaction with Plants in The Presence of Abiotic Factors	1.	Disease Triangle and the Contribution of the Environmental Factors in Influencing thePlant-microbe Interaction
		2.	Physiological and Molecular Basis for Predisposition or Endurance of Abiotic-biotic Stress Interaction Plantduring Abiotic-biotic Stress Interaction

Theory

Block 1: Plant Pathogen Interaction

Unit 1: Introduction to Plant Pathogen Interaction

Introduction to plant microbe interaction and importance, the concepts of holobiome and hologenome, Differences between endophytes/ rhizosphere/phylloplane microbes and phytopathogens, Types of endophytes/rhizosphere/phylloplane microbes, and their classifications

Unit 2: Genetic Basis of Host Pathogen Interaction

Genetics of immune response, Signal perception, Host-pathogen interaction (bacteria, fungus and virus), Nature of resistance to diseases-pathogenecity genes *(pat)* in plant pathogens-disease specific genes *(dsp), avirulence genes (avr), avr gene – coded proteins-structure of avr genes,* Transmission of the alarm signal to host defense producers: signal transduction, pathogen elicitors, protein kinases, calcium ions, phosphorylases, phospholipases, ATPases, Accumulation of Phytoalexins as a Resistance mechanism-Biosynthesis and metabolism of Phytoalexins, Modes of action of Phytoalexins, Pathogenesis-Related proteins (PR) and Disease Resistance- intro- Characterization and biological functions of PR proteins, Biosynthesis of PR proteins.

Unit 3: Growth Regulators of Plant Defense and Susceptibility

Regulation of hormones countering the pathogen infection and toxins modulating the plant physiology, ABA-SA cross talk and role of JA during plant interactionbiotrophic and necrotrophic pathogens respectively.

Unit 4: Bioenergetics in Plant Pathogen Interaction

An overview of energy-capture and energy-utilization processes in higher plant, Energy-capture and utilization process as affected by pathogenic infection, Molecular basis of pathogenesis and the process of interaction- classical examples of pathogens causing necrosis, wilts, tumours and soft rots, Role of primary metabolism in plant-pathogen interaction.

Block 2: Plant-Endophytes/ Rhizosphere/ Phylloplane Microbes Interaction

Unit 1: Interaction of Endophytes/ Rhizosphere/ Phylloplane Microbes with Plants

Approaches to study endophytic/ rhizosphere/ phylloplane microbes bacteria and fungi, Intracellular bacteria 'Cytobacts', Possible mechanisms of host plant genotype influence in recruitment of endophytic microbes vertical/ seed transmission, Inter- kingdom signaling regulating endophyte/ rhizosphere/phylloplane microbes development, Adaptation with respect to colonization of endophytes/ rhizosphere/ phylloplane microbes.

Unit 2: Role of Endophyte/ Rhizospheric/ Phylloplane Microbiota in Plant Physiological Processes

Phytohormones role in beneficial endophyte/rhizospheric/ phylloplanerecruitment, Hormonal regulation of assimilate partitioning in plant-microbe interactions, Plant- Fungus-Bacteria, the three fold interaction for improved plant nutrition.

Unit 3: Endophyte/ Rhizospheric/ Phylloplane Microbes in Improving Biotic and Abiotic Stress Tolerance

Importance in imparting stress (biotic and abiotic) adaptations, in the regulation of bioactive compound (alkamide) accumulation; acclimatization of root-interacting fungi for improved plant nutrition and stress tolerance, Cultivable versus uncultivable endophytes with respect to their extent of tissue colonization and diversity, Genetic engineering of endophytes for production of industrially important bioactive compounds, endophyte-enrichment technologies in crops for traits manipulation, Role of existing microbiome on introduced endophyte, symbiotic microbes and their interaction, Modern techniques for examining plant-microbe- insect interactions.

Unit 4: Bioethics, Biosafety, Intellectual property rights and implications in plant-microbe research

DBT biosafety regulations on working with microbial organisms associated with plants, Standard operating procedure (SOP), Committees dealing with biosafety and safe release of microorganisms.

Block 3: Microbial Interaction with Plants in the Presence of Abiotic Factors

Unit 1: Disease Triangle and the Contribution of the Environmental Factors in Influencing the Plant-microbe Interaction

Disease triangle involving plant-pathogen-environment and the importance of environmental stresses (drought, heat, humidity and soil factors) in influencing the resistance or susceptibility, Role of environmental factors in influencing establishment and sustenance of introduced beneficial microbes.

Unit 2: Physiological and Molecular Basis for Predisposition or Endurance of Plant during Abiotic-biotic Stress Interaction

Plant-water relations and changes in physiology in deciding the microbe interaction with plants, Metabolites in deciding the microbe interaction with plants, Hormonal cross talk, signal transduction, role of R-genes and other defense pathways during the simultaneous exposure to abiotic stress.

Practicals

- *In-planta* bacterial/fungal multiplication in plant under drought stress
- Detection of plant pathogens using molecular tools
- Stomatal conductance in plants under drought stress and pathogen stress
- Apoplast isolation from plants subjected to bacterial infection
- Virus induced gene silencing in plants
- Acetylene reduction assays to check nitrogen fixation in plant (The effect of beneficial microbes in plant)
- Biochemical analyses of beneficial and pathogen-effector proteins
- Plant colonization and disease or growth promotion scoring
- In-vivo detection of plant immune responses and their inhibition by effectors
- Estimation of phytoalexins, PR proteins, ACC deaminase and growth hormones in pathogen challenged plants
- Effect of plant microbe interaction on plant physiological processes, viz. photosynthesis, chlroroplast, transpiration, etc.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)

– Student presentation
– Practicals

Learningoutcome

By the end of this course, the student will be able to:

1. Understand how beneficial microbes enhance the planti mmune system
2. Comprehend how beneficial microbes stimulate plant growth
3. Describe plant-microbe interaction
4. Understand plant defense and susceptibility

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PPH 610 WEED BIOLOGY AND PHYSIOLOGY OF HERBICIDE ACTION (2+0)

Objectives

Weed sposea serious threat to Crop production leading to a yield loss ranging from 30% to some times total failure.Weed management is a significant in put on part of the producers. Chemical weed management through herbicides have been the most effective among various methods. Various herbicides with different modes ofactions are used to control weeds. Prolonged chemical control has led to adverse environmental consequences and development of herbicide resistance. There is a need to understand the biology of weeds as well as herbicideactions at physiological and molecular levels for resistance management as well as development of moreeffective and less harmful chemicals for weed management. The aim of this course will be to apprise the students about the seaspects of chemical weed control.

Aim of this course

The course is designed to provide both basic and applied knowledge on the weeds. It will help to understand the fundamental physiology, biochemistry, and molecular biology of herbicides and their effects on plants; To study the physiological and molecular mechanisms of herbicide resistance.

This course will provide knowledge on biology of weeds, classification and modeofaction of herbicides, herbicide resistance and its management and environment friendly weed managements trategies.

The course is organized as follows:

No.	Blocks		Units
1	Weed Biology	1. 2. 3.	Weed Biology and its Importance in Weed Management Life Cycle and Population Dynamics of Weeds Crop Weed Competition
2	Physiology of Herbicide Action	1. 2. 3.	Introduction to Herbicides Mechanism of Action of Herbicides Herbicide Resistance and its Management

Theory

Block 1: Weed Biology

Unit 1: Weed Biology and its Importance in Weed Management

Introduction to weeds, Classification of weeds, Yield losses caused by weeds, Environmental impacts of invasive weed species, Aspects of Weed biology,Germination, Dormancy and growth behaviour of weed species, Effect ofenvironmental factors on weeds, Adaptation of weeds to different ecologies

Unit 2: Life Cycle and Population Dynamics of Weeds

Growth duration and reproductive potential of weed species, Population dynamics, Weed Shift due to weed management, weed Seed Bank,

Unit 3: Crop Weed Competition

Understanding the nature of crop-weed competition, critical stages of crop weed competition, growth stages of weeds for improved control by herbicides

Block 2: Physiology of Herbicide Action

Unit 1: Introduction to Herbicides

Introduction, Chemistry and classification of herbicides by mechanism of action, HRAC Classification, Site of Actions, Application techniques, doses, activeherbicides, Methods to increase the efficiency of soil and foliar applied herbicide – role of membranes, adjuvants, surfactants, synergists,

Unit 2: Mechanism of Action of Herbicides

Physiological and biochemical effects of herbicides: Effects on membrane structure and functions, cell division and cell development, Effects on chloroplast, photosynthesis, respiration, protein synthesis, synthesis of lipids, Molecular mechanism of action, Molecular mechanisms of herbicide resistance in relation to chloroplast gene expression,

Unit 3: Herbicide Resistance and its Management

Herbicide resistance-Definition, history, magnitude; Mechanisms of resistance: Target site and non-target site, cross and multiple resistances, Role of management practices on resistance development, Resistance management: Strategies; HR crops, Super weeds.

Teaching methods / activities

- Lectures
- Assignment (Reading/Writing)
- Text Books/reference books and materials
- Student presentations

Learning outcome

After successful completion of this course, the students are expected to be able to:

- Understand the importance of weed biology in weed management
- Understand the mechanism of herbicideaction
- Understand the problem of herbicide resistance development
- Appreciate and suggest sustainable weed management strategies

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Ph.D. in Seed Science and Technology

Course Code	Course Title	Credit Hours
SST 601	Hybrid Seed Production Technology	3 (2+1)
SST 602	Organic Seed Production	2 (1+1)
SST 603	Physiology and Biochemistry of Seeds	2 (1+1)
SST 604	Genetic Purity and DUS Testing	3 (2+1)
SST 605	Seed Vigour and Crop Productivity	2 (1+1)
SST 606	Advances in Seed Science	2 (2+0)
SST 607	Advances in Seed Quality Enhancement	2 (1+1)
SST 608	Germplasm Conservation Techniques	2 (1+1)
SST 609	Seed Ecology	2 (1+1)
SST 610	Seed Planning, Trade and Marketing	2 (1+1)
	Total	**22 (13+9)**
SST 680	Qualifying Examination	3 (0+3)
SST 681	Seminar - I	1 (0+1)
SST 682	Seminar - II	1 (0+1)
SST 683	Teaching Assistantship - I	1 (0+1)
SST 684	Teaching Assistantship - II	1 (0+1)
SST 691	Research - I	18 (0+18)
SST 692	Research - II	18 (0+18)
SST 693	Research - III	18 (0+18)
SST 694	Research - IV	18 (0+18)

SST 601 HYBRID SEED PRODUCTION TECHNOLOGY (2+1)

Objective

To provide students a comprehensive knowledge and practical exposure on hybrid seed production techniques in agricultural and horticultural crops.

Theory

Block –1: Importance of hybrids

Unit 1: Introduction - history - scope - importance of hybrid development - national and international scenario of seed industry - popular public sector hybrids in various crops. Heterosis - definition - expression - types - utilization of heterosis in hybrid development, hybrid vigour and seed vigour.

Unit 2: Types of hybrids - intra-specific, inter-specific hybrids, single, double, three way cross, top cross hybrids - apomixes; generation system of seed multiplication in different types of hybrids. Development and maintenance of inbred lines - male sterile - maintainer lines - fertility restoration - transgenic hybrids - principles and method of development.

Block –2 : Hybrid seed production techniques

Unit 1: Breeding tools - genetic mechanism - male sterility - types : CMS, GMS, CGMS, TGMS, PGMS - barnase and barstar system - pistillateness - self incompatibility. Manual creation of male sterility - emasculation and pollination - gametocides - mode of action, mechanism.Synchronization of flowering - problems - methods to achieve synchrony - planting ratio and supplementary pollination methods.

Block –3: hybrid seed production in agri. and horticultural crops

Unit 1: Techniques of hybrid seed production in major agricultural crops - cereals (wheat, rice), millets (maize, sorghum, bajra), pulses (red gram), oilseeds (sunflower, castor, mustard), cotton and forage crops.

Unit 2: Hybrid seed production techniques in horticultural crops - tomato, brinjal, chilli, bhendi, onion, bitter gourd, bottle gourd, ridge gourd, cucumber, melon, cabbage, cauliflower, potato, coconut and papaya.

Practicals

- Characteristics features of parental lines and their hybrids
- Floral biology of rice, maize, pearlmillet, sunflower, castor and cotton
- Study on floral biology of vegetable crops - solanaceous and other vegetables
- Study on floral biology of cucurbitaceous crops
- Production and maintenance of A, B and R lines
- Practicing planting design and border rows - rice, maize, pearlmillet, sunflower and red gram; brinjal and chillies
- Practicing planting design and border rows in tomato, cotton and cucurbitaceous vegetables
- Manipulation for synchronization - rice, sunflower, pearlmillet and sorghum
- Practicing supplementary pollination - rice and sunflower
- Practicing field inspection in hybrid seed production plot - crops planted in ratio - sunflower, pearlmillet, sorghum *etc.,*
- Practicing field inspection in hybrid seed production field - red gram, castor, cotton, cucurbits and tomato.
- Practicing roguing and identification of off-types - pollen shedders - shedding tassel - selfed fruits.
- Visit to hybrid seed production fields
- Visit to potato seed production plots
- Determination of cost benefit of hybrid seed production
- Visit to seed Industry and assessing problems and perspectives in hybrid seed production

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SST 602 ORGANIC SEED PRODUCTION (1+1)

Objective

To make students to understand the concept of organic farming, principles and practices of organic seed production, certification and marketing.

Theory

Block –1: Importance of organic farming

Unit 1: Organic farming - definition, genesis, concepts and principles; importance of organic farming and organic seed; organic seed - strategies, problems and perspectives - organic seed vs conventional seed; organic seed production - factors influencing seed production - soil health - GMO elements of seed.

Unit 2: Techniques of organic seed production - selection of land - pre requisite for seed production - conversion period - soil amendments - green manures; multi-varietal seed techniques - organic sources of manures - bulky, concentrated and liquid manures, bio fertilizers and bio control agents - organic seed treatment.

Block 2 : Post harvest techniques and certification of organic seed

Unit 1: Organic methods to weed management practices - manual and mechanical methods - mulching - thermal weed control; growth promoting substances - panchakavya, fish amino acid etc.; organic plant protection measures - herbal insecticides - IPM strategies; post-harvest techniques - drying, processing and grading; organic seed treatment and storage.

Unit 2: Organic certification application - registration - verification of records; organic seed certification - tagging; role of organizations in production and marketing of organic seed - national and international organizations involved - public, private - NGOs - International Federation of Organic Agriculture Movement (IFOAM) - basic standards and EU regulations - organic seed marketing.

Block 3: Economics of organic seed production

Unit 1: Crop specific organic seed production and post-harvest seed management techniques for major food crops, vegetables and fruit crops - economics of organic seed production and demand for organic seed.

Practicals

- Studying the field and seed standards for organic seed production
- Collection and identification of organic manures and liquids
- Preparation of organic products for soil application
- Preparation of panchakavya, starter solutions and vermiwash
- Organic priming of seeds with panchakavya and vermiwash
- Preparation of leaf extracts and starter solutions and preparation of organic products for foliar application
- Studying the effect of organic nutrients and foliar sprays on seed quality
- Preparation of organic products for seed treatment and studying the effect on seed quality
- Assessing the storage behaviour of organically treated seeds
- Selection of suitable container and dry leaves or shrubs for enhanced storability
- Organic treatment for management of seed health
- Production and assessment of bio control agents for effective pest control
- Economics of organic seed production and assessing demand
- Visit to organic farm and seed production field
- Visit to Department of organic certification
- Visit to organic retail shops
- Classroom lectures
- Group assignments and presentation

- Laboratory and field experiments
- Demonstration
- Field visits

References

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SST 603 PHYSIOLOGY AND BIOCHEMISTRY OF SEEDS (1+1)

Objective

To provide insight knowledge on physiological and biochemical events governing seed quality and its survival.

Theory

Block 1 : Role of cell organelles

Unit 1: Seed development and maturation - role of cell organelles - embryogeny - translocation of assimilates - synthesis of starch, protein, lipid, secondary metabolites and toxic compounds - possible alteration in metabolic pathway.

Unit 2: Development of embryo, endosperm and seed coat - translocation of assimilates and food reserves; desiccation tolerance -

mechanism, hypothesis, role of LEA proteins; development of hard seeds - mechanisms and factors.

Block 2: Seed dormancy and germination

Unit 1: Seed dormancy - types - physiology and biochemistry of seed dormancy induction and release - hormonal regulation of seed dormancy - environmental control - genetic inheritance and control of dormancy; physiology of orthodox, recalcitrant and intermediate seeds.

Unit 2: Seed germination - acquisition of viability and capacity of germination during development - genetics of germination acquisition; types of germination - phases of germination - requirements - imbibition - enzyme activation and hormonal regulation - respiration - mitochondrial activity and ATP synthesis - protein and nucleic acid synthesis - metabolism of starch, protein, lipid - physiology of embryo growth and development.

Block 3 : Seed deterioation

Unit 1: Seed deterioration - theories, causes - ultra-structural, cell membrane and functional changes; biochemical changes - enzyme activity, storage reserves and genetic changes; lipid peroxidation - biological effects - free radicals and secondary products.

Practicals

- Study on the pattern of seed development and maturation
- Study on the structural changes during seed maturation
- Estimation of seed moisture content, fresh and dry weight and acquisition of germination and dormancy
- Estimation of different hormones during seed development and maturation - GA and ABA content
- Estimation of phenolic compounds during seed maturity
- Estimation of food reserves accumulation - starch, protein and oil at different stages of maturity
- Study on the pattern of seed development in recalcitrant seeds
- Studying the germination behaviour of different type of seeds

- Study on imbibition pattern and soaking injury in seeds
- Estimation of enzymes in dormant and non-dormant seeds
- Estimation of hormones in dormant and non-dormant seeds
- Studying the effect of light and temperature on dormancy
- Study on deterioration pattern of orthodox and recalcitrant seeds
- Estimation of lipid peroxidation product and free fatty acid
- Studying the cytological and chromosomal changes in deteriorated seeds
- Estimation of volatile aldehydes during seed storage and deterioration
- Classroom lectures
- Assignments and presentations

References

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SST 604 GENETIC PURITY AND DUS TESTING (2+1)

Objective

To impart knowledge on various methods of genetic purity assessment and DUS testing for protection of plant varieties.

Theory

Block 1 : Genetic purity test by GOT, chemical and biochemical methods

Unit 1: Genetic purity - importance - factors influencing genetic purity; genetic / cultivar purity test - objectives - principles - methods; laboratory tests - green house and field plot methods, grow - out test, seed and seedling growth tests; chemical and biochemical methods; anthocyanin pigmentation, secondary compounds, phenol, peroxidase and fluorescence tests - chromatography techniques.

Block 2 : Genetic purity by molecular marker

Unit 1: Electrophoretic analysis of proteins and isozymes; DNA finger printing methods - RAPD, AFLP, SSR, SNP and other markers; computer based machine vision technique and image analysis for varietal identification.

Unit 2: Genesis of Plant Variety Protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions - GATT agreement in relation to plant variety protection; Protection of Plant Varieties and Farmer's Rights (PPV& FR) Act 2001 - objectives, salient features, farmer's rights, breeder's rights, researcher's rights - PPV& FRA Rules 2003.

Block 3 : New plant varieties protection

Unit 1: Criteria for protection of new varieties of plants; Distinctness, Uniformity and Stability (DUS) testing - principles and procedures, guidelines, sample size, test duration, testing option; varieties of common knowledge - extant variety - essentially derived variety - collection of reference samples - grouping of varieties - example varieties; types and categories of characters - recording observations on characteristics - colour characteristics.

Unit 2: Assessment of DUS characters of major crops based on morphological, biochemical and molecular markers - rice, maize, wheat, barley, black gram, green gram, red gram, cowpea, rajma, sunflower, groundnut, castor, mustard, tomato, brinjal, onion, potato, chilli, bhendi, cucurbits, cole crops, sugarcane, cotton, flower, fruit and tree species; statistical procedure - computer software for DUS testing; guidelines for registration of germplasm - impact of plant variety protection on seed industry growth.

Practicals

- Genetic purity assessment based on seed characters
- Genetic purity assessment based on seedling growth tests, anthocyanin pigmentation
- Genetic purity assessment based on secondary compounds, phenol, peroxidase and fluorescence tests

- Chromatography analysis of secondary compounds Electrophoretic analysis of seed protein and isozymes
- DNA fingerprinting using PCR techniques.
- DUS testing based on morphological descriptors of plant - rice and millets
- DUS testing based on morphological descriptors of plant - pulses and oil seeds
- DUS testing based on morphological descriptors of plant - vegetable crops
- DUS testing based on morphological descriptors of plant - flower, fruit and tree species
- Recording observations and interpretation of data
- Tree method of classification of varieties / cultivars
- Chemical and biochemical test applicable for DUS testing.
- Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major agricultural crops
- Practical exercise on recording DUS characteristics, statistical analysis and interpretation in major horticultural crops
- Visit to DUS test centers

References

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SST 605 SEED VIGOUR AND CROP PRODUCTIVITY (1+1)

Objective

To impart knowledge on seed vigour, vigour test, impact of seed vigour on seed production, storage and seed management.

Theory

Block 1 : Seed vigour and its importance

Unit 1: Seed vigour - importance, concepts, definitions, vigourvs viability, historical development - ISTA vigour committee. Factors influencing seed vigour - genetic, agronomic, biotic and abiotic factors.

Unit 2: Seed vigour and senescence - sequence of vigour loss - manifestations of seed vigour - physical, physiological, biochemical and molecular manifestations; vigour in relation to seed dormancy and germination; vigour in relation to value for cultivation and use.

Block 2 :Vigour tests

Unit 1: Vigour tests - history - definition - characteristics - types - direct and indirect tests - physical test - x-ray radiography, seed size; physiological test - seedling first count, radicle emergence, speed of germination, seedling measurement; stress tests - brick gravel test, cool test, cold test, paper piercing test, ethanol, ammonium chloride and NaCl soak tests, accelerated ageing test, exhaustion test, controlled deterioration test, osmotic stress test.

Unit 2: Chemical and biochemical tests - electrical conductivity test, free sugars and amino acids, tetrazolium chloride test, respiration quotient, GADA test, free fatty acid, DPPH, respiratory and hydrolytic enzymes tests, modern vigour tests - machine vision, Q2 analyzer - standardization of vigour test.

Block 3: Influence of seed vigour on crop growth

Unit 1: Influence of seed vigour - crop growth, field emergence, productivity and storage; vigour of vegetative propagules; role of seed vigour in field emergence, crop growth, yield and productivity. Seed vigour improvement and management techniques - pre-sowing and pre-storage - mid storage methods to improve seed vigour.

Practicals

- Collection and evaluation of germination of seed lots with different vigour status
- Evaluation of seed vigour by physical vigour test - seed size, colour, weight - turbidity test
- Evaluation of seed vigour by physiological vigour test - imbibition pattern, speed of emergence, radicle emergence, germination, seedling measurement and computation of various index
- Conducting different stress tests - brick gravel and paper piercing tests
- Conducting accelerated ageing and controlled deterioration test
- Conducting chemical stress test - NH_4Cl, NaCl, mannitol, PEG test
- Special vigour tests - cool germination test - cold test - anaerobic test
- Biochemical vigour test - electrical conductivity, free sugars and amino acid test in seed leachate
- Estimation of dehydrogenase enzyme activity
- Estimation of free fatty acids in seed lots in varying vigour levels
- Bio-assay test for seed vigour
- Estimation of volatile aldehydes in different crop seeds with varying vigour
- Correlation studies between field emergence and different vigour tests

- Seed vigour on field establishment, population maintenance and crop growth and productivity
- Pre-sowing vigour management techniques
- Pre-storage and mid storage vigour management techniques.
- Classroom lectures
- Assignment and presentation
- Slides/video shows
- Practical exercise
- Hands on training

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SST 606 ADVANCES IN SEED SCIENCE (2+0)

Objective

To impart knowledge on the recent developments in various frontier areas of seed science and their application in seed technology.

Theory

Block 1 : Physiological and molecular aspects of seed development

Unit 1: Physiological and molecular aspects of seed development - gene expression during seed development - selective elimination of cells - theories and concepts; physiological and molecular regulation of germination and dormancy; desiccation and stress tolerance - gene expression - mechanism - structural changes in membranes of developing seeds; prediction of seed dormancy and seed longevity using mathematical models; climate change effects on pollination, seed formation, development and quality.

Block 2: Recent Techniques in Seed Science

Unit 1: Recent techniques in seed production of self-incompatible, protogyny, protandry and apomictic plant species - Gene Use Restriction Technology (GURT) - terminator and verminator technology - Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) Cas - gene editing; seed proteomics - principles, methods, applications in seed science- genetic analysis and QTL mapping of traits related to seed vigour, ageing and longevity - OMICS in related to seed science and technology; somatic embryogenesis - principles and methods of production of synthetic / somatic seeds - merits and demerits.

Unit 2: Modern techniques for identification of varieties and hybrids - principles and procedures; DNA fingerprinting and other molecular techniques and their utilization - GM seeds and their detection techniques; Use of machine vision and image analysis techniques for varietal identification. Application of artificial intelligence (AI) and machine learning (ML) and virtual reality (VR) in seed science.

Block 3: Seed Enhancement Research

Unit 1: Recent accomplishments in seed enhancement research - seed coating, pelleting and priming techniques - physiological, molecular and sub-cellular basis of seed priming - detection and identification of seed borne diseases and insect pests through advanced techniques - ELISA and PCR based techniques.

Unit 2: International movement of seeds - OECD seed certification schemes - recent developments in seed laws and policies - ethical issues and IPR system related to seed trade and movement.

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SST 607 ADVANCES IN SEED QUALITY ENHANCEMENT (1+1)

Objective

To impart knowledge on seed quality enhancement techniques and their associated quality changes in seed.

Theory

Block 1 : Seed Enhancement Techniques

Unit 1: Seed quality - importance and enhancement - principles, concept, significance, strategies; types of seed enhancement - physical, physiological and biological enhancement techniques.

Unit 2: Physical seed quality enhancement - concept and principles of grading - upgrading - magnetic, electromagnetic, irradiation, coating, pelleting, colouring; plasma treatment - thermal and cold plasma - treatment; application of nano formulations - concepts - principles - mode of action on improving germination.

Block 2: Advance Techniques in Seed Enhancement

Unit 1: Physiological methods of seed quality enhancement - seed priming – principles, methods, mode of action - physiological, biochemical and molecular mechanism of priming techniques; seed infusion - principles and methods, mode of action - imparting abiotic stress tolerance - hardening - principles and methods.

Unit 2: Application of biological formulations - bacterial, fungal agents - concepts, formulations and compatibility; methods of application - growth promotion - protection - control over pest and disease infection and mode of action; designer/ smart seed - concept, methods, applicability to different crops.

Block 3: Influence of seed enhancement techniques on crop establishment

Unit 1: Effect of different treatments on crop establishment and modulation of seedling growth - crop geometry, phenology and yield improvement; storability of primed, coated and pelleted seeds - pre-storage and mid-storage enhancement techniques - hydration-dehydration techniques, moisture equilibrium drying and halogenations - principles, methods and application.

Practicals

- Physical seed quality up gradation - specific gravity separator, density grading, floatation technique
- Practicing seed pelleting - methods of pelleting for different crop species
- Performing seed coating - polymer, colouring and nano emulsion coating
- Study on the effect of magnetic and electromagnetic seed treatment on seed germination and vigour
- Practicing seed priming - hydro, osmo, halo and solid matrix priming methods
- Nutrient and bio priming and assessing the performance of primed seeds
- Assessing the storability of primed seed
- Study on seed hardening on the performance of seed under abiotic stress
- Preparation of designer/ smart seed for different crops
- Biological seed treatment - biological formulations, bacteria, fungi, protectants and bio fertilizers
- Study on the effect of biological seed treatment on seedling growth and disease incidence
- Estimating the microbial population in biologically treated seeds
- Assessing the storability and vigour potential of treated seeds
- Performing mid-storage seed treatment - hydration-dehydration, moisture equilibrium and drying
- Halogenation of seeds and their effect on seed performances
- Assessing the performance of treated seeds under field condition
- Classroom lectures,
- Student assignments and presentation
- Field and laboratory experiments
- Demonstration

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SST 608 GERMPLASM CONSERVATION TECHNIQUES (1+1)

Objective

To impart technical knowledge on the current issues and techniques of germplasm conservation for sustainable utilization in agriculture.

Theory

Block 1 : Biodiversity conservation

Unit 1: Biological diversity in India - importance - need for conservation - concept of natural reserves and gene banks; post-exploration handling of germplasm collections, preservation of seed and plant specimens, importance and use of herbaria; in-situ conservation - components - biosphere reserve - natural park; factors influencing conservation; in-situ conservation - national programmes - on farm conservation.

Unit 2: Ex-situ conservation - components - plant genetic resources conservation in gene banks - national gene banks - gene repositories - seed gene bank - types of collections - base, active and working collections - perma-frost seed conservation - guidelines for sending seeds to gene bank; handling of orthodox and recalcitrant seeds for conservation - clonal repositories.

Block 2: Methods of conservation

Unit 1: Methods of in vitro conservation - short, medium and long term, concept of active and base in vitro genebank; in-vitro storage - culture maintenance - problems and perspectives - gene bank maintenance for temperate and tropical fruit crops, spices, tubers, bulbs, medicinal and aromatic plants; conservation of embryos and ovules, meristem, cell / suspension cultures - protoplast and callus cultures - pollen culture - micro propagation techniques - genetic stability under long term storage.

Block 3: Advanced conservation methods

Unit 1: Cryopreservation - principle and method - handling of orthodox and recalcitrant seeds for cryopreservation - cryoprotectants -

desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation and dehydration techniques; application of cryopreservation techniques for agricultural, horticultural and forest crops.

Unit 2: Gene bank standards for various crops - monitoring viability of stored seed samples - multiplication and regeneration of stored germplasm materials - National and International organizations - NBPGR and NPGRI - roll and functions; Dooms-day safe seed vault - Biodiversity International - conservation guidelines.

Practicals

- Study on In-situ conservation methods and case studies
- Plant exploration, germplasm collection and documenting passport data
- Ex-situ techniques for long term conservation of germplasm collections
- Preparation and handling of materials, packaging and documentation
- Preparation of seed album and herbarium specimens for ex-situ conservation
- Planning and designing of cold storage units and facilities for gene bank
- Conservation protocols for orthodox seeds
- Study of conservation protocols for recalcitrant seeds
- Conservation techniques for vegetative propagules / clones
- Cryopreservation techniques - encapsulation, dehydration, freezing, thawing methods
- Cryopreservation of in-vitro cultures - meristem, embryo, cell suspension and pollen cultures
- Study on freezing and vitrification techniques
- Conservation technique of forest tree species
- Study on in vitro cryo-genebanking and database management

- Visit to national and regional seed gene banks and university gene bank
- Visit to on-farm conservation sites and Botanical Survey of India
- Classroom lectures
- Student assignment and presentation
- Practical experiments
- Exposure / field visits

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SST 609 SEED ECOLOGY (1+1)

Objective

To study the influence of ecology on seed production, reproductive biology, seed dispersal, longevity and adaptation mechanisms and to study the effect of pollutants on seed production and quality.

Theory

Block 1: Seed Ecology and its influence on seed quality

Unit 1: Introduction to ecology - seed ecology - importance - genetic effects - geographic adaptation of native and invasive species; ecological factors on seed germination and regeneration; reproductive allocation - reproductive effort; flowering phenology, assessment of resource allocation - positional and azimuth influence on flowering and reproduction; influence of climate change on reproduction, seed formation, germination and dormancy.

Block 2: seed dispersal system

Unit 1: Seed dispersal - definition - modes of dispersal, dispersal dynamics, aerial seed dispersal, pre and post dispersal hazards, seed predators and ecological significance.Seed polymorphism - types, causes, consequences on seedling adaptation.

Unit 2: Soil seed bank - definition - classification - soil seed bank dynamics. Thermodynamic models - population dynamics in soil seed bank - seed longevity and germination models in soil seed bank - weed seed ecology and longevity - long term experiments in buried seeds; ecological significance of seed dormancy and seed polymorphism.

Block 3: Seed ecology on seed storage

Unit 1: Influence of environment on seed germination - allelopathy, temperature, light, moisture and gaseous environment - eco-physiological role in seed storage.

Unit 2: Effect of pollutants - air, water and soil pollutants on seed germination and seedling establishment - factors limiting seedling establishment - problem soils and seed management techniques - climate change and seed production - management strategies to overcome the effect of climate change on seed production and germination.

Practicals

- Understanding flowering phenology of different crop species
- Study of seed dispersal mechanism of different crop species
- Study on agents and distance of dispersal of different crop species
- Studies on pre and post dispersal hazards
- Assessing the natural regeneration in relation to ecology
- Assessing the problems related to natural regeneration
- Experiment on naturally buried seeds - dormancy and longevity
- Studies on effect of environmental factors on seed germination and dormancy
- Influence of seed polymorphism on germination and dormancy
- Assessing the allelopathy effect on seed germination in crop species
- Effect of soil pollutants on seed germination
- Effect of air pollutants on germination of crop seeds
- Effect of water pollutants on growth on seed quality
- Seed management practices for polluted environment and climate change effects
- Visit to in-situ and ex-situ conservation sites
- Visit to biological hotspots

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SST 610 SEED PLANNING, TRADE AND MARKETING (1+1)

Objective

To impart knowledge on planning seed production programmes, national and international movement of seeds and marketing strategies.

Theory

Block 1: Genesis of seed industry

Unit 1: Seed industry – genesis, history and growth – structure of seed industry in India –mission and objectives of seed Industry; status and role of seed industry in Indian agriculture.

Unit 2: Seed production programmes – characters, types; planning and organizing seed programmes in public and private sectors–small, medium, large and more advanced seed programmes – local, national and international seed programmes; seed demand forecasting – purpose – methods and techniques – factors determining seed demand –seed multiplication ratio, seed replacement rate and variety replacement rate; seed production planning for varieties and hybrids – compact area approach and seed village – contractual seed production – custom seed production – public private partnership–transgenic seeds–demand assessment.

Unit 3: New seed policy – genesis – functions; WTO – Indian seed industry–patenting and suigener is system–The Seeds Bill, 2004 and 2011; role and contributions of MNC's in seed trade in India; International trade of seeds – government policies –International organizations involved in seed movement and trade–International Seed Federation(ISF), ISTA–OECD seed schemes–operational guidelines; import and export of seeds – Exim policies – guidelines and salient features; seed production and quality control systems in SAARC Nations and other developed countries; quarantine measures–procedures, guidelines and certificates in international seed movement and trade.

Unit 4: Seed production and distribution system in central and state governments, co-operative and private organisations – seed marketing – definition, concept, importance and type of markets – domestic and global market – problems and perspectives; marketing polices – seed marketing schemes, marketing channels – responsibilities of dealers–marketing mix; handling and management of sales return seed stocks.

Unit 5: Seed pricing–local market rate–factors affecting prices and pricing policies fixation of procurement and sale price of seeds–cost analysis–seed market intelligence – marketing promotional activities; seed supply chain management–missing link–risk and management.

Practical

a. Data collection on status of Indian and global seed industry;

b. Planning seed programmes for varieties and hybrids;

c. Planning for establishment of small and medium seed enterprises;

d. Planning for establishment of large scale seed enterprises;

e. Planning for custom seed production and contractual seed production;

f. Assessment of seed demand–demand forecasting methods;

g. Assessment of seed multiplication ratio, seed replacement rate and variety replacement rates for different crops;

h. Study on the economics of seed production and marketing;

i. Exercise on fixing procurement and sale price of seeds;

j. Studyofseedmarketingchannels–survey and interaction with seed dealers and distributors;

k. Visit to plant quarantine station and study of quarantine requirements and certificates for domestic and international seed trade;

l. Visit to modern seed processing unit, advanced seed storage complex and interactions;

m. Visits to state seed corporations;

n. Visit to MNCs and expert discussion;

o. Case studies and SWOT analysis;

p. Planning for establishment of new seed ventures and project preparations;

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Ph.D. in Sericulture

Course Code	Course Title	Credit Hours
SER 601	Advances in Genetics and Breeding of Mulberry	2 (1+1)
SER 602	Physiology and Nutrition of Mulberry	2 (1+1)
SER 603	Physiology and Nutrition of Silkworm	2 (1+1)
SER 604	Physiological and Biochemical Genetics of Silkworm	2 (1+1)
SER 605	Silkworm Pathology	2 (1+1)
SER 606	Integrated Pest Management in Sericulture	2 (1+1)
SER 607	Sericulture Biotechnology	2 (1+1)
SER 608	Vanya Silk Technology	2 (1+1)
SER 609	Seri-Business Management	2 (1+1)
SER 610	Post Silk Reeling Technology	2 (2+0)
	Total	**20(11+9)**
SER 680	Qualifying Examination	3 (0+3)
SER 681	Seminar -I	1 (0+1)
SER 682	Seminar - II	1 (0+1)
SER 683	Teaching Assistantship -I	1 (0+1)
SER 684	Teaching Assistantship - II	1 (0+1)
SER 691	Research -I	18 (0+18)
SER 692	Research -II	18 (0+18)
SER 693	Research -III	18 (0+18)
SER 694	Research -IV	18 (0+18)

SER 601 ADVANCES IN GENETICS AND BREEDING OF MULBERRY (1+1)

Objective

- To make the students be acquainted with advances in genetics, cytogenetics and advanced breeding methods for mulberry improvement

Theory

Block 1: Origin and distribution of mulberry, germplasm and biometrical techniques

Unit 1: Origin and cytogenetics of the genus *Morus*

Origin and exploitation of the genus *Morus*. Species of mulberry and their distribution. Wild species and local genotypes and their importance. A critical appraisal of taxonomy of genus *Morus*. Mode of reproduction in relation to breeding methods in mulberry and genetic constitution. Recent advances in cytology of mulberry - Karyomorphology, mitosis and meiosis. Recent advances in embryology. Ploidy levels of mulberry.

Unit 2: Conservation and maintenance of mulberry germplasm

Different types of mulberry conservation. Role of mulberry germplasm in mulberry improvement. Characterization and evaluation of mulberry germplasm for morphological, anatomical, physiological, reproductive, biochemical and molecular traits. Evaluation of commercially released varieties/ genotypes for different growth and yield parameters. Utilization of mulberry gene bank. National and international institutes involved in mulberry germplasm conservation.

Unit 3: Biometrical techniques in breeding

Introduction, Assessment of variability**:** simple measures of variability, Components of variance -Genetic diversity. Aids of selection**:** Correlation coefficient analysis, Path analysis-Discriminant function. Choice of Parents and Breeding procedures: Partial diallel analysis, Line x Tester analysis - Biparental cross analysis. Varietal adaptation: Components of adaptability, Assessment of stability.

Block 2: Conventional and non-conventional breeding methods for mulberry improvement

Unit 1: Conventional methods of mulberry breeding

Procedures followed for different methods of conventional breeding- Introduction, mass selection and clonal selection. Handling of segregating progenies-pedigree selection and back cross method of selection. Exploitation of heterosis, different kinds of heterosis, estimation of heterosis in mulberry. Three tier system of evaluation of mulberry. Advances in conventional methods of breeding. Poly cross hybrids – Principles involved, advantages and dis advantages. Steps in development of polycross hybrids. Advanced generation breeding. Preliminary yield evaluation, multilocational trial and mulberry authorization for evaluation. Steps for orderly distribution of improved varieties. Release of new varieties. Multiplication system and distribution-Kisan nursery-important varieties developed in conventional method.

Unit 2: Non-conventional methods of breeding

Present status of mulberry varietal improvement through mutation. Importance of induced mutation, recent achievements in mulberry mutation breeding. Limitations of mutation breeding.

Polyploidy, induction of polyploidy in mulberry, special features of triploids in mulberry, process of triploid mulberry development, varieties developed by polyploidy breeding in mulberry. Breeding methods followed for leaf quality parameters, biotic and abiotic stress. Breeding strategies for climate change. Participatory plant breeding (PPB) – introduction, types, stages of participation, objectives, advantages of PPB, role of farmers in PPB.

Unit 3: Biotechnological approaches for mulberry improvement

Recent advances in application of plant tissue culture. Applications of molecular markers in mulberry improvement. Genome characterization Development of transgenic mulberry – procedure. Nanotechnology: introduction, main features and its applications. Plant Variety Protection Act (PVPA) – Introduction, types of protection, basic requirements, organizations, procedure, material to be protected, types of varieties, exemptions under PVPA, advantages and disadvantages of PVPA. Statistical approaches for yield tests in mulberry: Field plot techniques in mulberry breeding experiments. Different experimental designs-RCBD, Augmented Randomized Complete Block Design (ARCBD) and LSD.

Practicals

- Geographic distribution of the genus *Morus* and mapping;
- Evaluation of mulberry germplasm maintained at the Department of Sericulture, UAS, GKVK, Bengaluru;
- Study of diversity of mulberry germplasm maintained at the Department of Sericulture, UAS, GKVK, Bengaluru;
- Collection and categorization of available mulberry germplasm using standard key;
- Studies on conservation and maintenance of mulberry gene bank;
- Identification of suitable mulberry genotypes for tree mulberry;
- Characterization of suitable mulberry genotypes and quality parameters for chawki silkworms;
- Characterization of suitable mulberry genotypes and quality parameters for late age silkworms;
- Identification of suitable mulberry genotypes for fruit purpose;
- Evaluation of commercially released mulberry varieties for growth and yield parameters;
- Phenotypic evaluation of commercially released mulberry varieties;
- Hands on training in callusing, sub-culturing,root initiation, shoot initiation and hardening of tissue culture plants, Triploids, etc.;
- Active bud treatment for polyploid induction in mulberry;
- Layout of field experiments in mulberry;
- Testing for resistance to biotic stresses;
- Testing for resistance to abiotic stresses;
- Selective breeding using marker assisted selection for identifying WUE mulberry genotypes;
- Visit to CSGRC Hosur/ CSB.

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- *Indian Silk*, Central Silk Board, Bangalore
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- *Korean Journal of Sericultural Sciences*
- *Sericologia*, International Sericultural Commission, India
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Websites

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SER 602 PHYSIOLOGY AND NUTRITION OF MULBERRY (1+1)

Objective

- To provide an understanding of physiological and nutritional management of mulberry plant
- To provide information on the factors affecting absorption of nutrients and water, pathway of minerals, transpiration, photosynthesis, cellular respiration and biotic and abiotic stress.

Theory

Block 1: Mulberry Physiology

Unit 1: Factors affecting sprouting and establishment of cuttings

Factors affecting sprouting and establishment of cuttings. Effect of temperature, cold, frost, light and salt. Recent advances in hydroponics and aeroponics with their significance in moriculture.

Unit 2: Bud sprouting and rooting of cuttings

Role of hormones in bud sprouting and rooting of cuttings and other physical agents like temperature, RH, light and water.

Block 2: Growth and development of mulberry

Unit 1: Vegetative growth and development of mulberry

Duration of vegetative period, leaf area development, phases of development in different age groups of plants (Bush and tree type).

Block 3: Plant growth hormones

Unit 1: Plant growth hormones and growth regulators

Plant growth hormones and growth regulators, classification, nature and biosynthesis in different aged plants and their functions.

Block 4: Photoperiodism and thermoperiodism

Unit 1: Photosynthesis in mulberry

Photosynthesis in mulberry. Factors affecting photosynthesis, light and dark reaction, stages of photosynthesis, Calvin cycle, C-4 pathway and productivity.

Unit 2:Respiration in mulberry

Respiration – Cellular respiration - glycolysis, fermentation, citric acid cycle and Electron Transport Chain. Transpiration – role of environmental factors affecting transpiration,

Unit 3: Photoperiodism

Role of photoperiodism in flowering, fruit set and seed development.

Block 5: Water and nutrient absorption mechanism

Unit 1: Soil properties and nutrient uptake

Role of physical and chemical properties of soil on nutrient uptake and growth. Absorption pattern of major and micro nutrients in different soils.

Unit 2: Nutrient use and INM in mulberry

Response of mulberry varieties to absorb N, P, K and micronutrients. Soil fertility status and INM principles.

Unit 3: Role of water in mulberry physiology

Functions of water ecophysiology of plant, absorption of water, passive absorption and active absorption, pathway of minerals, root pressure.

Block 6: Dormancy and stress physiology

Unit 1: Dormancy in mulberry buds and seeds

Viability of buds and seeds, concept of plant stress, biotic and abiotic stress, effect of water deficit stress on mulberry.

Unit 2: Abiotic and biotic stress in mulberry

Effect of temperature, cold, frost, light and salt on mulberry growth and development. Physiological changes during diseases.

Block 7: Nutrient deficiency symptoms

Unit 1: Deficiency symptoms of major nutrients

Deficiency symptoms of N, P and K, toxicity of these nutrients in mulberry plants and their effect on quality of mulberry, reclamation of the soils by soil application, foliar application and fertigation methods.

Unit 2: Deficiency symptoms of secondary and micro nutrients

Key deficiency symptoms of S, Mn, Fe, Mo, Mg, Ca, Zn and other micronutrients and toxicity of these nutrients in mulberry plants and their effect on quality of mulberry, reclamation by soil and foliar application and fertigation methods.

Practicals

- Study of sprouting and rooting in different varieties of mulberry;
- Use of different concentrations of plant growth hormones for establishment of mulberry;

- Root and other growth parameters relevant in establishment of mulberry;
- Study of transpiration and photosynthesis in mulberry;
- Study of leaf area measurement of different varieties of mulberry;
- Study of different nutrients and their effect on growth and development of mulberry;
- Study of deficiency symptoms of NPK in mulberry;
- Study of mulberry seed viability tests;
- Study of biochemical and mineral composition of leading mulberry varieties;
- Study of different nutrient deficiency symptoms in mulberry;
- Study of respiration in mulberry;
- Evaluation of popular mulberry genotypes for abiotic and biotic stresses;
- Effect of various proportions of soil amendments on growth and development of mulberry;
- Study of deficiency symptoms of secondary and micro nutrients in mulberry;
- Visit to aeroponic units at Department of Crop Physiology, UAS, GKVK, Bengaluru;

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SER 603 PHYSIOLOGY AND NUTRITION OF SILKWORM (1+1)

Objective

- The course is designed to empower students on advances in physiology of silkworm for successful silkworm rearing

Theory

Block 1: Importance and Scope

Unit 1: Silkworm physiology and its application in commercial silkworm rearing

Study of importance of silkworm physiology, progress in developed countries - Japan, China, Korea and in India.

BLOCK 2: Advances in silkworm Physiology

Unit 1:Physiology of digestion and excretion

Physiology of digestion and excretion, metabolism of carbohydrates, lipids, proteins, amino acids, vitamins, minerals, excretory physiology, water conservation and utilization in the body.

Unit 2: Physiology of circulation and respiration

Physiology of blood circulation and respiration. Haemolymph its composition- types of cells in the haemolymph *viz*., phagocytes, leucocytes, oenocytoids, spheroid cells, etc. and their role, synthesis of blood, role of enzymes and hormones in circulation. Physiology of respiration, O_2 supplementation.

Unit 3: Physiology of endocrine system

Physiology of endocrine system- Neurosecretory cells, prothoracic gland, corpora allata, corpora cardiac and sub-oesophageal gland. Growth and development, moulting, diapauses pro-synthesis of pheromones and their role in regulating silkworm behaviour. PTTH, JH analogues, physiology of moulting and spinning.

Unit 4: Physiology of silk synthesis

Physiology of silk synthesis, Pro-synthesis of fibroin and sericin, role of Lyonet's /Pilippi's gland, Molecular basis of silk protein synthesis- sericin and fibroin.

Unit 5: Nutrition of silkworms

Utilisation of mulberry leaves, nutritional requirement of silkworms, digestion and utilization of various nutrients, digestive enzymes, metabolism of various kinds of nutrients, carbohydrates, proteins, amino acids, vitamins and minerals.

Block 3: Applied aspect of physiological studies

Unit 1: Applications of Hormones

Commercial application of tricontinol, serimore, sampoorna JH analogues and moulting hormones.

Unit 2: Preparation of artificial diets

Preparation of artificial diets for silk productivity. Classification of diets- diet with mulberry leaf powder and diet without mulberry leaf powder. Nutrient supplementation.

Practicals

- Study of consumption indices of carbohydrates utilization;
- Study of consumption indices of protein and lipid utilization;
- Study of amylase activity in digestive juice of different breeds of silkworm;
- Study of esterese activity in egg, haemolymph and silkglands of different breeds of silkworm;
- Study of acid phosphatase activity in haemolymph and alkaline phosphatase in digestive juice of different breeds of silkworm;
- Determination of free amino acids in the haemolymph of silkworm;
- Determination of trehlose content in the haemolymph of silkworm;
- Application of hormones on growth and development of silkworms;
- Evaluation of plant products for growth and productivity in silkworm;
- Application of JH analogues and study its influence on growth and development of mulberry silkworm;
- Application of MH analogues and its influence on growth and development of mulberry silkworm;
- Determination of NAD-dependent sorbitol dehydrogenase activity during egg diapause;
- Nutrition supplementation through leaf fortification and its studies on growth and development;
- Preparation of artificial diets with mulberry component;
- Preparation of artificial diets (synthetic) without mulberry leaf powder;
- Visit to CSTRI/ NSSO;
- Visit to SERICARE/ Crop Physiology lab;

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SER 604 PHYSIOLOGICAL AND BIOCHEMICAL GENETICS OF SILKWORM (1+1)

Objective

- The course in designed to make the students realize that silkworm development is influenced by the various physiological processes which are in turn governed by specific genes
- The student learns the relationship between these processes, the biochemical pathways and the genes that influence these processes and pathways.

Theory

Block 1: Developmental Genetics

Unit 1: Embryonic development

Embryonic development of non-hibernating and hibernating eggs; parthenogenesis; development of embryos under special genetic conditions, i.e., controlled by E- group allele, NC gene, NI-gene.

Unit 2: Post-embryonic development

Induction and translocation of quantitative and qualitative traits in silkworm. Quantitative traits affected by maturity genes, influence of environmental conditions on the expression of quantitative characters. Inheritance of moultinism, voltinsim and juvenility.

Block 2: Physiological genetics

Unit 1: Genetics of Physiology in silkworm

Genetic control of hormonal mechanism. Role of voltinism genes on determination of quantitative characters. Maternal inheritance and its biochemical aspects. Genetic analysis of cocoon colours; physiology of pigments, genetic relation in terms of pigment permeability and transmission.

Unit 2: Biochemical genetics in silkworm

Genetic basis of enzymes – amylase – esterase – alkaline phosphatase – acid phosphatase – proteins and blood cells – haemocytes – ultrastructure of silk gland and silkprotein synthesis – glutinous protein of the mucous gland. Importance of developmental, physiological and biochemical genetics in silkworm management, nutrition and breeding.

Practicals

- Silkworm embryo testing and preparation of slides;
- Embryonic development in non – diapausing eggs;
- Embryonic development in diapausing eggs;
- Linkage maps and regional differentiation of the chromosomes;
- Induction of parthenogenesis in silkworm, *Bombyx mori* L.;
- Study of induction of polyploidy in silkworm;
- Maternal inheritance in mulberry silkworm;
- Inheritance of voltinism and moultinism in silkworm;
- Maternal inheritance and biochemical aspects;
- Genetics of cocoon colour in *Bombyx mori* L.;
- Sex determination in mulberry silkworm;
- E-group alleles as a tool for developmental genetics;
- Silkworm nutrition in relation to breeding;
- Preparation of artificial diets for mulberry silkworm, *Bombyx mori* L.;
- Biochemical genetics: genetic basis of enzymes activity;
- Estimation of amylase activity in different races of silkworm;

- Determination of NAD-dependent sorbitol dehydrogenase activity in the diapausing eggs of *Bombyx mori* L.;
- Assessment of environmental influence on expression of quantitative traits;

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SER 605 SILKWORM PATHOLOGY (1+1)

Objective

- The course is structured to provide advanced information on the viral, bacterial, protozoan and fungal diseases of silkworm as well as their prevention and control measures
- The course aims to provide knowledge to diagnose and identify different types of infections, knowledge on the etiological factors and their interactions

Theory

BLOCK 1: Viral diseases of silkworm

Unit 1: Viral diseases of silkworm

Introduction to silkworm viral diseases. Economic importance, classification of silkworm viruses. Symptomatology and diagnosis of viral infections of silkworm. Purification of viruses and serological techniques. Nature, size and morphology of nuclear polyhedrosis virus, cytoplasmic polyhedrosis virus, infectious flacherie virus, densonucleosis virus.

Unit 2: Prevention and control of viral diseases of silkworms

Predisposing factors, disease cycle, other hosts and spread of viral diseases. Interaction among silkworm viruses. Histopathology and pathophysiology of viral infections. Prevention and control.

Block 2: Bacterial diseases of silkworm

Unit 1: Importance of bacterial diseases of silkworm

Introduction, history and importance of Bacterial diseases of the silkworm. Mixed infections. Etiology of bacterial flacherie, morphology and chemistry, pathogenicity, route of infection, silkworm immunity.

Unit 2: Bacterial diseases- symptomatology, prevention and control

Introduction, bacterial septicemia, bacterial diseases of digestive organs. History and importance of bacterial toxicosis of the silkworm. Structure and chemistry, biosynthesis of protein and chemistry of crystal toxin, histopathology, pathophysiology, Prevention and control.

Block 3: Protozoan and fungal diseases of silkworm

Unit 1: Protozoan diseases - pathogens, symptomatology, prevention and control

Introduction, history and importance of the pathogenic protozoans of silkworms. Biodiversity, isolation, purification, morphology and chemistry of pathogenic protozoans. Strains of Microsporidians infecting silkworm and their life-cycle. Symptoms at the various stages of the life cycle of silkworm, pathologies, routes of infection, alternative hosts, cross infectivity, survival and spread, detection, prevention and control.

Unit 2: Fungal diseases - pathogens, symptomatology, prevention and control.

Introduction to fungal diseases, economic importance and classification of fungal diseases of silkworms, general morphology of Deuteromycetes. Life cycle of the different fungi pathogenic to silkworms-white, green, yellow, black, red muscardines and *Aspergillus* disease. Pre- disposing factors, symptomatology, pathology (histopathology and pathophysiology), host range, host susceptibility, prevention and control.

Practicals

- Diagnosis of viral and bacterial diseases of silkworm based on external symptoms;
- Diagnosis of protozoan and fungal diseases of silkworm based on external symptoms;
- Isolation and purification of silkworm viral pathogens;
- Isolation and purification of silkworm bacterial pathogens;
- Staining techniques for silkworm viruses and bacteria;
- Identification of silkworm pathogens based on morphology;
- Infectivity techniques for silkworm diseases;
- Cross infectivity of mulberry lepidopteran pests to silkworm;
- Cross infectivity of pathogens of silkworm pathogens to mulberry lepidopteran pests;
- Purification of pebrine pathogens;
- *In-vitro* evaluation of chemicals against protozoan and fungal pathogens of silkworm;
- *In vivo* evaluation of effective chemicals against protozoan and fungal pathogens;
- Life cycle studies of important bacterial and fungal pathogens of silkworm;
- Interactions among different silkworm pathogens in silkworm;
- Practising hygienic measures in silkworm rearing for prevention of silkworm diseases;
- Practising shoot rearing method with net method of bed cleaning for prevention of silkworm diseases;
- Application of bed disinfectants against different diseases of silkworm;
- Application of room disinfectants to eliminate silkworm pathogens;
- Visit to Silkworm Pathology laboratory of CSB and State Sericulture Institute

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SER 606 INTEGRATED PEST MANAGEMENT IN SERICULTURE (1+1)

Objective

- The course is structured to improve knowledge on pests, factors affecting their biotic potential, damage caused, bio-ecology and integrated managements of pests of mulberry and non-mulberry silkworm food plants.
- Eco-friendly management practices for these pests will also be taught.

Theory

Block 1: Pest and Pest Outbreak

Unit 1: Pests, classification and damage

Concept of pests, classification of insect pests. Types of damage caused to host plants of silkworms and assessment of extent of damage.

Unit 2: Pest outbreak, pest surveillance and forecasting

Causes for insects assuming pest status. Factors affecting the natural balance of insects in mulberry eco-system. Pest surveillance and forecasting of outbreaks.

Block 2: Pest Management

Unit 1: Principles and concept of pest management

Principles and of pest management. Integrated pest management – Meaning, practical utilization and merits.

Unit 2: Eco-friendly pest management

Eco-friendly pest management – concept, incorporation in IPM package, benefits. Development of cultural and mechanical methods, botanicals, other animal derived insecticides and biological control in IPM.

Block 3: Bio –Ecology and Integrated Management of Pests

Unit 1: Mulberry Pests

Bio-ecology and IPM of root feeding, steam boring, leaf eating and sap sucking pests of mulberry.

Unit 2: Mulberry silkworm uzifly

Biology of mulberry silkworm uzifly in relation to the biotic and abiotic environment and IPM package for the pest.

Unit 3: Grainage pests

Pests encountered in mulberry silkworm egg production centres, damage caused and their management.

Unit 4: Pest of non-mulberry silkworm food plants

Incidence and extent of damage caused by pests on castor, *Terminalia* and som. Biology of important defoliators and effect of ecological factors and IPM of important pests.

Unit 5: Pests of non-mulberry silkworms

An account of biology of pests and predators of tropical and temperate tasar silkworms and muga silkworm. Pests of eri silkworm. IPM of *Blepharipa zebina, Canthecona furcellata* and bird predators of tropical tasar.

Practicals

- Survey and collection of insect pests of mulberry and their classification;
- Observations on nature and extent of damage and loss occurred to mulberry;

- Sampling methods for pest surveillance;
- Incidence of termites on different varieties of mulberry;
- Incidence of jassids, black headed hairy caterpillar and leaf folder on mulberry;
- Incidence of white mealy bug on different mulberry varieties;
- Life cycle of black headed hairy caterpillar on mulberry and castor;
- Biology of mulberry leaf webber and its varietal preference and IPM;
- Integrated management of rootknot nematode of mulberry;
- Study of botanical pesticides and bio-agents used in mulberry pest management;
- Forms, formulations and application of pesticides;
- Safety of insecticides, their permissible limits and safety periods in mulberry pest management;
- Incidence and biology of uzifly on mulberry silkworm;
- Construction of life table for indian uzifly based on the available data;
- Study of biological control agents used in uzifly management;
- Integrated management of mulberry silkworm uzifly;
- Survey for insect and non-insect pests in mulberry silkworm grainage;
- Study of pests of castor and *Terminalia* spp. and their management;
- Visit to CSGRC, Hosur/ R & D institutions.

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SER 607 SERICULTURE BIOTECHNOLOGY (1+1)

Objective

- The course is designed to equip the students with recent developments in the field of tissue culture techniques, molecular markers, mapping and sequencing and recombinant DNA technologies applied both in mulberry and silkworm improvement

Theory

Block 1: Biotechnology in sericulture

Unit 1: Perspective, scope and current status of biotechnology in Sericulture

Perspective, scope and current status of biotechnology. Techniques adopted in Restricted Fragment Length Polymorphism (RFLP), Random Amplified Polymorphic DNA (RAPD), Amplified Fragment Length Polymorphism (AFLP) and Simple Sequence Repeats (SSR). Applications of PCR (Polymerase chain reaction) and agarose gel electrophoresis.

Unit 2: Mapping and sequencing of mulberry and silkworm

Mapping and sequencing of mulberry and silkworm. Genome of mulberry and silkworm. Molecular basis for improvement of yield components in mulberry and silkworm.

Block 2: Tissue culture and recombinant DNA techniques

Unit 1: Tissue culture in mulberry

Micro propagation in mulberry, Production of haploids and Double haploids (DH) lines, Synthetic seeds, Induction of *in-vitro* flowering, *In vitro* screening of mulberry for different stress conditions. Somaclonal and Gametoclonal variations - their scope and applications. Cryopreservation in mulberry for germplasm preservation. Protoplast culture and somatic hybridization.

Unit 2: Recombinant DNA techniques in mulberry and silkworm

Recombinant DNA techniques in mulberry and silkworm. Role of agents and microorganisms with emphasis on common vectors for gene transfer. Stability and expression of transferred genes in mulberry and silkworm. Germline transformation and scope of genetic manipulation between silkworm breeds. Application of molecular techniques in gene identification for further breeding programmes. Application of site directed mutagenesis, gene targeting and gene therapy. Silkgland genetics.

Units 3: Seri bioinformatics

Seri bioinformatics- introduction, branches of bioinformatics, computer programmes used application in crop improvement. Studies on Genomics- genomics in crop improvement, types of genomics: structural and functional, applications, achievements and limitations. Studies on proteomics, metabolomics. Nano technology- introduction, features and application of nano technology in mulberry improvement.

Practical

- RFLP marker technique as applied to mulberry crop, improvement;
- RFLP marker technique as applied to silkworm improvement;
- RAPD marker technique as applied to mulberry crop improvement;
- AFLP marker technique as applied to mulberry crop improvement;
- SSR marker technique as applied to mulberry crop; Equipments and chemicals used in RFLP and RAPD techniques;
- Equipments and chemicals used in PCR technique;
- Hands on training in mulberry DNA extraction, isolation and purification;
- Hands on training in silkworm DNA extraction, isolation and purification;
- Mulberry DNA quantification and quality assessment;
- Silkworm DNA quantification and quality assessment;
- Procedure of Agarose gel electrophoresis;
- Application of PAGE in silkworm;
- PCR reaction and DNA amplification;
- Estimation of genetic distances- cluster analysis in mulberry;
- Estimation of genetic distances- cluster analysis in silkworm;
- Visit to Seribiotech. Lab. of CSB at Kodathi;

- Visit to MAS lab and biotechnology lab of UAS (B);
- Visit to CSR&TI, Mysore- biotechnology division.

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SER 608 VANYA SILK TECHNOLOGY (1+1)

Objective

- This course is designed to provide advanced aspects of non-mulberry sericulture
- Provide deep insight to reeling technology of commercially exploited non mulberry silkworms

Theory

Block 1: Scope of non-mulberry sericulture

Unit 1: Introduction and spread of non-mulberry sericulture

Introduction, spread of non-mulberry sericulture in the world and India and its utility to tribal people.

Unit 2: Non-mulberry sericigenous insects

Different non-mulberry sericigenous insects - fagara silk, coan silk and anaphe silk.

Block 2: Commercially exploited non-mulberry silks

Unit 1: Physical characteristics – Eri, Tasar and Muga cocoons

Cocoon colour, shape, size, compactness, peduncle and ring in respect of Eri, tasar, muga, anaphe, fagara and coan silk cocoons.

Unit 2: Commercial characteristics- Eri, Tasar and Muga cocoons

Cocoon weight, shell weight, shell percentage, filament length, denier, kakame, non-breakable filament length, reelability, raw silk percentage with respect to Eri, tasar, muga, anaphe, fagara and coan silk cocoons.

Block 3: Reeling technology for non-mulberry silk cocoons

Unit 1: Reeling technology for non-mulberry silk cocoons

Cocoon stifling and cooking methods, brushing, processing, wet and dry reeling of tasar and muga cocoons. Various equipments for reeling- Devedi, N.R. Das and CTRS imporved reeling machine for tasar cocoon reeling and Choudhari reeling machine for muga silk cocoons, drying and skein making. Semi-automatic and Automatic Reeling Meachines. Testing and grading of non-mulberry silks.

Block 4: Spinning of Eri silk cocoons and By-product utilization

Unit 1: Spinning of Eri silk cocoons

Definition of spun silk, Various steps involved in spun silk industry (processing, degumming, washing and drying), Eri cocoons as raw material for spun silk industry- spinning of eri cocoons, hand spinning using Natwa, Takli, machine spinning using Amber charaka, madleri charaka and finished products, characteristic features, production of spun silk from pierced tasar and muga cocoons on takli, bhir and N.R. Das spinning wheel.

Unit 2: By-products of non-mulberry silk industry and their utilization

Use of different types of tasar wastes, by-products of tasar reeling - gicha, katia and matka silks. Use of pierced cocoons of Tasar and

Muga, cooking waste, reeling waste and pelade layer. Silk wastes, extraction of pupa oil and its use in various fields. Pupa oil mill.

Block 5: Economics of non-mulberry silk reeling establishments

Unit 1: Organization of non- mulberry silk reeling units

Organizational set up of reeling and spinning establishments for Tasar, Muga and Eri. Site for reeling, facilities for reeling and requirement of human skill and resources for reeling and spinning. Calculation of quantity of cocoons for different reeling and spinning units based on the raw material required for the available appliances. Working out of economics of reeling taking into account the cost of production and returns from resultant raw silk in respect of Tasar and Muga. Economics of eri spinning.

Block 6: Conventional and non- conventional energy, health and environmental hazards in silk reeling industry

Unit 1: Use of conventional and non-conventional energy in silk reeling industry

Overview, energy/ wood/ fuel/power consumption in cocoon stifling, cooking and reeling- release of smoke, constituents of smoke – effect of smoke on human health and rearing environment. Effluents from silk production. Solid waste, dust, smoke and effluents from silk weaving factory and spun silk mills.

Unit 2: Health and environmental hazards in silk reeling

Effect of reeling industry on ecosystem. Occupational health risk on reelers/ workers – skin and lungs related problems in reeling units due to release of smoke. Constituents and effect of smoke on human health and environment. Effluents from silk production. Solid waste, dust, smoke and effluents from silk weaving factory and spun silk mills. Policies on pollution control programmes on health hazards – risk and proposed options.

Practicals

- Collection and preservation of different stages of non-mulberry silkworms;
- Study of biodiversity of non-mulberry silk fauna on different hosts;

- Study of marketing system of cocoon transaction of tasar;
- Study of marketing system of cocoon transaction of muga;
- Study of marketing system of cocoon transaction of eri;
- Study of physical parameters of the tropical tasar and muga cocoons;
- Study of physical parameters of the eri cocoons;
- Study of physical parameters of Japanese, Chinese and temperate tasar cocoons;
- Study of commercial parameters of different ecoraces of tropical tasar;
- Study of commercial parameters of muga and eri silk cocoons;
- Study of different methods of stifling for tasar and muga cocoons;
- Study of different methods of cooking for tasar and muga cocoons;
- Study of use of enzymes in tasar cocoon cooking;
- Study of different reeling machinery for tasar and muga;
- Study of different spinning appliances for eri cocoons;
- Visit to spun silk mill to study the spun silk production;
- Visit to Central Silk Technological Research Institute, Bengaluru;
- Estimation of cost and returns of reeling and spun silk units.

References

- BHASKAR, R. N. AND GOVINDAN, R., 2005, *Techniques in Silk Reeling*, Department of Sericulture, UAS,GKVK, p. 50.
- GANGA, G., 2003, *Comprehensive Sericulture.* Volume 2. *Silkworm Rearing and Silk Reeling.* Oxford & IBH, New Delhi, p.429.
- JOLLY, M. S, SEN, S. K, SONWALKAR, T. N. AND PRASAD, G. K., 1972, *Manual on Sericulture-IV. Non mulberry silks,* FAO, Rome, p.178.
- KIM, B. H., 1978, *Raw Silk Reeling,* Korean edition Seoul Publishing Company, p. 275.
- *Manual on Bivoltine silk Reeling Technology*, 2003, Published by JICA, PPP BST Project, p-122.

Journals

- *Indian Journal of Sericulture*, Central Silk Board, Bangalore
- *Indian Silk*, Central Silk Board, Bangalore
- *Seridoc*, Central Silk Board, Bangalore
- *Journal of Sericultural Science Japan*, Japan
- *Korean Journal of Sericultural Sciences*
- *Sericologia*, International Sericultural Commission, India.
- *Bulletin of Indian Academy of Sericulture*.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in
- www.csrtimys.res.in/

SER 609 SERI-BUSINESS MANAGEMENT (1+1)

Objective

- The students will know and understand the business opportunities and their management in various activities of sericulture. Learn about constraints and risk management

Theory

Block 1: Silkworm seed production management

Unit 1: Sericulture industry-An overview

Overview, concept and principles of management, personal and resource management.

Unit 2: Management of silkworm seed production

Silkworm seed production management – organizational set up, selection of site, ground plan and establishment of grainage, production, planning, raw material, manpower, seed storage programme, marketing, record maintenance; case studies.

Block 2: Leaf production and silkworm rearing programme management

Unit 1: Leaf production and supply management

Quality mulberry leaf production and supply management

Unit 2: Synchronized silkworm rearing programme management

Synchronized silkworm rearing programme – manpower, community rearing, silkworm rearing house management, marketing of cocoons.

Block 3: Silk reeling unit management

Unit 1: Management of silk reeling unit

Reeling unit management – organizational set up, raw materials-cocoons, fuel and water.

Unit 2: Constraints and risk management

Manpower, procurement skills, constraints in silk reeling, marketing of silk. Case studies in charka, cottage basin and filature basin. Management of by-products of sericulture. Risk and non-cash input management in silk reeling units.

Practical

- Resource management in sericulture enterprise;
- Study of organizational set up in sericultural organizations;
- Production planning for grainage;
- Management of raw material in grainage operations;
- Reeling unit management: Management of man power, raw material, fuel and water;
- Planning for establishment of chawki rearing centre (CRC);
- Planning for establishment of grainage;
- Study of by-products in sericulture;
- Record maintenance for sericulture activities;

- Study of leaf production and supply chain management;
- Risk management/ non cash management in sericulture;
- Visit to grainage and CRC;
- Case studies: chawki rearing unit and silk cocoon production;
- Case study: silkworm seed production unit;
- Case studies: filature and cottage basin units;
- Case studies: charaka unit and improved Charaka units;
- Visit to seed cocoon markets;
- Visit to silk reeling units.

References

- ANONYMOUS., 2002, *Silk Weaving*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- ANONYMOUS., 2002, *Colours from Nature – Silk Dyeing Using Natural Dyes.* Vol. I and II, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- BERNARD, P. AND CORBMAN., 1983, *Textiles: Fiber to Fabric*. 6th Edition, Mc. Graw-Hill International Editions, Home Economic Series, Singapore, p. 594.
- CHARLES, J. HUBER., 1929, *The Raw Silk Industry of Japan*. The Silk Association of America, Inc., New York.
- DANDIN, S. B. AND GUPTA, V. P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
- DANDIN, S. B., JAYANT JAYASWAL. AND GIRIDHAR, K., (Eds.)., 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore.
- DATTA, R. K., 1996, *Global Silk Scenario–2001. Proceedings of the International Conference on Sericulture – 1994.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- GOVINDAN, R., CHINNASWAMY, K. P., KRISHNAPRASAD, N. K. AND REDDY, D. N. R., 2000, *Non-Mulberry Sericulture,*

Silk Technology and Sericulture Economics and Extension. Vol. 3—Proceedingsof NSTS–1999, UAS, Bangalore.

- SINHA, S., 1990, *The Development of Indian Silk*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- TRIPURARI SHARAN., 1984, *Sericulture and Silk Industry*. Published by Y.K. Sharma, Consortium on Rural Technology, Delhi.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – Published by NASSI, Bangalore.
- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.
- *Current Science* – C.V. Raman Institute of Science, Bangalore.
- *Reshme Krishi* (Kannada) – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in
- www.csrtimys.res.in

SER: 610 POST SILK REELING TECHNOLOGY (2+0)

Objective

The course is aimed at emphasizing on post reeling techniques for the production of quality silk fabrics.

Theory

Block 1.Preparatory silk weaving

Unit 1: Silk throwing- soaking and drying, winding, doubling, twisting-types of twisting. Steam setting of twisted yarn. Warping, types of warping with different nature of fibres and yarn winding.

Unit 2: Degumming of silk; Methods of degumming, effect of temperature, time of dipping and equipment's used for degumming. Wet processing- sources and quality of water. Bleaching and dyeing, classification of dyes, factors influencing dyeing, preparation of dyes and methods of dyeing.

Block 2. Silk Weaving

Unit 1: Weaving-loom and its structure, different types of looms-plain loom, semi-automatic loom, automatic loom and shuttleless loom. Types of shuttles, speed of shuttle. Arrangement of yarn for simple weaving and design weaving. Visit to cottage-weaving units.

Unit 2: Printing and methods of printing -block and screen printing, Textile Designing, Motifs for weaving and textile printing, silk/fabric finishing, silk knitting. Disposal of effluents.

References

- ARNOLD, W., 2020, *Theory of Silk Weaving: A Treatise on the Construction and Application of Weaves, and Decomposition and Calculation of Silk Fabrics.* Hansebooks, India. P-108.
- EIRI BOARD, 2008, *Modern Technology of Bleaching, Dyeing, Printing and Finishing of Textiles.* Engineers India Research Institute,P-331.
- MAHADEVAPPA, D., HALLIYAL, V. G., SHANKAR, D. G. AND BHANDIWAD, R., 2000, *Mulberry Silk Reeling Technology.* Oxford and IBH Publishing Co. Pvt. Ltd., P-234.
- MURUGESH BABU, K., 2018, *Silk: Processing Properties and Applications* (2nd Edition). Elsevier,P-272.
- SONWALKAR AND TAMMANNA, N., 1993, *Handbook of Silk Technology,* New Age International (P) Ltd., P-336.

Ph.D. in Soil Science

Course Code	Course Title	Credit Hours
SSC 601	Recent Trends in Soil Physics	2 (2+0)
SSC 602	Modern Concept in Soil Fertility	2 (2+0)
SSC 603	Physical Shemistry of Soil	2 (2+0)
SSC 604	Soil Genesis and Micro Morphology	2 (2+0)
SSC 605	Bio-Chemistry of Soil Organic Matter	2 (2+0)
SSC 606	Soil Resource Management	3 (3+0)
SSC 607	Modeling of Soil Plant System	2 (2+0)
SSC 608	Clay Mineralogy	3 (2+1)
SSC 609	Recent Trends in Soil Microbial Biodiversity	3 (2+1)
	Total	**21 (19+2)**
SSC 680	Qualifying Examination	3 (0+3)
SSC 681	Seminar -I	1 (0+1)
SSC 682	Seminar - II	1 (0+1)
SSC 683	Teaching Assistantship -I	1 (0+1)
SSC 684	Teaching Assistantship - II	1 (0+1)
SSC 691	Research -I	18 (0+18)
SSC 692	Research -II	18 (0+18)
SSC 693	Research -III	18 (0+18)
SSC 694	Research -IV	18 (0+18)

SSC 601 RECENT TRENDS IN SOIL PHYSICS (2+0)

Objective

To impart knowledge in soil and water interactions, soil aeration, soil crust –clod formation, solar terrestrial and radiation measurement.

Theory

Block I

Unit 1: Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, soil-plant-atmospheric continuum (SPAC).

Unit 2: Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow.

Unit 3: Theories of horizontal and vertical infiltration under different boundary conditions.

Unit 4: Movement of salts in soils, models formiscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

Block II

Unit 1: Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil; Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.

Unit 2: Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture.

Unit 3: Solar and terrestrial radiation measurement, dissipation and distribution in soil- crop systems; prediction of evapo transpiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra- red thermometer.

References

- ARUNA KUMAR SAHA - Text book of Soil Physics
- RATHANLAL & MANOJ SHUKLA - Principles of Soil Physics
- DILIP KUMAR DAS - Introductory Soil Science
- ISSS, New Delhi - Fundamentals of Soil Science
- DANIEL HILLEL - Introduction to Soil Physics

SSC602 MODERN CONCEPT IN SOIL FERTILITY (2+0)

Objective

To study the nutrient availability, uptake mechanisms, chemical equilibrium, concept of soil fertility evaluation and interpretation for better plant growth and development.

Theory

Block I

Unit1: Nutrient availability – concept and relationships, modern concepts of nutrients availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices.

Unit 2: Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micro nutrients in soils.

Unit 3: Chemical equilibria (including solid-solution equilbria) involving nutrients in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit 4: Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

Block II

Unit 1: Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

Unit 2: Monitoring physical, chemical and biological changes in soils; permanent manorial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit 3: Carbon-a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.

References

- ISSS, New Delhi - Fundamentals of Soil Science
- DILIP KUMAR DAS - Introductory Soil Science
- T. D. BIWAS AND S. K. MUKARJEE - Text book of Soil Science
- JADEJA, HIRPARA , VEKARIA AND SAKARVADIA - Soil Fertilizers and Nutrient Management
- BOYD ELLIS AND HENRY FOTH - Soil Fertility

SSC 603 PHYSICAL CHEMISTRY OF SOIL (2+0)

Objective

To study the colloidal chemistry of soil, predictive approaches, thermo dynamics, adsorption/desorption isotherms and common solubility equilibria in soils.

Theory

Block I

Unit 1: Colloidal chemistry of inorganic and organic components of soils-their formation, clay organic interaction.

Unit 2: Predictive approaches, for, cationexchange equilibria-thermodynamics, empirical and diffuse double layer theory (DDL)-relationships among different selectivity coefficients; structure and properties of diffuse double layer.

Unit 3: Thermodynamics of nutrient transformations in soils; Climate change effects on mineralogy and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.

Block II

Unit 1: Adsorption/desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

Unit 2: Common solubility equilibria-carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

References

- KIM H TAN - Principles of Soil Chemistry
- ISSS, New Delhi - Fundamentals of Soil Science
- D.K. DAS - Introductory Soil Science
- L. BATTACHARYA - Text book of Soil Chemistry
- BRADDY, N. C. - Nature and Properties of Soil

SSC 604 SOIL GENESIS AND MICRO MORPHOLOGY (2+0)

Objective

To impart knowledge on pedogenic evolution of soils, weathering, factors affecting soil formation, profile development and mirco pedological features of soils.

Theory

Block I

Unit 1: Pedogenic evolution of soils; soil composition and characterization.

Unit 2: Weathering and soil formation–factors and pedogenic processes; stability and weathering sequences of minerals.

Block II

Unit 1: Assessment of soil profile development by mineralogical and chemical analysis.

Unit 2: Micro-pedological features of soils–their structure, fabric analysis, roleingenesis and classification.

References

- J. SEHGAL - A Text book of Pedology
- ISSS, New Delhi - Fundamentals of Soil Science
- WILLY - Soil Morphology, Genesis and Classification

- RINGROSE VOASE AND HUMPHREY - Soil Micro Morphology
- SPRINGER - New trends in Soil Micro Morphology

SSC 605 BIO-CHEMISTRY OF SOIL ORGANIC MATTER (2+0)

Objective

To study the importance of organic matter in soil biochemistry, humus formation theories, nutrient transformation, functional groups of humic substances and humus pesticide instruction in soil.

Theory

Block I

Unit 1: Organic matter in soils and its maintenance Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration.

Unit 2: Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

Unit 3: Nutrient transformation–N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.

BlockII

Unit 1: Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.

Unit 2: Humus-pesticide interactions in soil, mechanisms.

References

- KYOICHI KUMADA - Chemistry of Soil Organic Matter
- F. J. STEVENSON - Humus Chemistry
- BOLLAG AND STOTZKY - Soil biochemistry
- E. A. PAUL - Soil biochemistry
- K. HAIDER - Soil biochemistry

SSC 606 SOIL RESOURCE MANAGEMENT (3+0)

Objective

To study the relevance of soil resource and sustainable land management, types, factors affecting land degradation, soil conservation, watershed management and agro ecological regions of India.

Theory

Block I

Unit 1: Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, gene reserves, and geogenic source of raw materials; soil as a source and sink of green house gases.

Unit 2: Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

Unit 3: Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diaralands. Management of forest, peat and muck soils.

Block II

Unit 1: Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, water logged and wet lands; land restoration and conservation techniques–erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.

Unit 2: Watershed management-concept, objectives and approach; water harvesting and recycling; flood control in watershed management;

socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.

Unit 3: Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

References

- A. K. KOLAY - Remote Sensing and Assessment of Soil Resource
- YUVA RAJ MUTHURAMAN AND MURNGARAGARAN RAMA SWAMY - A text book on Soil Resource and inventory and Problem Soil Management
- RATANLAL AND SHEWART - Principles of Sustainable Soil Manegement in Agroeco Systems
- ROBERT WHITE - Principles and Practice of Soil Science
- HENRY WANG - Principles of Soil Science

SSC 607 MODELLING OF SOIL PLANT SYSTEM (2+0)

Objective

To create awareness about the concepts of modeling, terms and definition, classification of models, high level computer language and models of spatially heterogenous and nutrient uptake.

Theory

Block I

Unit 1: Introduction, terms and definitions; classification of models; Taylor series; numerical methods of differentiation and integration.

Unit 2: High level computer language: FORTRAN-its commands and usage; testing and evaluation of model.

Unit 3: Description of spatially homogeneous models; K transformation model; nitrogen and phosphorus dynamics in soil.

Block II

Unit 1: Spatially heterogeneous models; equation of continuity; Simulation of water flow through soil; Explicit and Explicit-Implicit method; simulation of solute movement through soil with variable moisture flux by explicit-implicit method.

Unit 2: Nutrient uptake model: Integration of nutrient movement in soil (mass flow and diffusion) and uptake by plants (Michaelis-Menten kinetics); Nutrient uptake model: Solubility and free ion activity model.

References

- Plant System - ROLF NIEDER AND BENBI - Hand Book of Processes and Modeling in the Soil
- JOHN HANKS AND RITCHIE - Modeling Plant and Soil System
- MATHEWS & STEPHENS - Crop – Soil Simulation Models
- Advance in Crop Modeling for a Sustainable Agriculture - KENNETH BOOTE

SSC 608 CLAY MINERALOGY (2+1)

Objective

To teach the definitions of clay minerals concepts, crystallography, classification of silicate minerals, interstratified clay mineral, genesis and transformation and surface chemistry of clay minerals.

Theory

Block I

Unit 1: Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations, crystal systems.

Unit 2: Structures and classification of silicate minerals, basics of phyllo silicates, laws governing structural characteristics of phyllo silicates, Gold schmitdt's laws – Laws I and Law II, Classification of Phyllo silicates.

Unit 3: Kaolonite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins.

Unit 4: Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann-Marshal-Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils.

Unit 5: Micas: occurrence and origin in soils, poly types of micas, structure and formation of muscovites and illite.

Unit 6: Vermiculites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite.

Block II

Unit 1: Chlorite: occurrence and structure of chlorites, "swelling chlorites", formation of chlorite.

Unit 2: Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties.

Unit 3: Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

Unit 4: Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

Unit 5: Surface chemistry of clay minerals, clay-organic complexes, nano clay mineralogy.

Unit 6: Clay minerals in different soil orders, role of clay minerals in soil fertility management.

Practical

- Separation of clay for mineralogical study
- X-ray diffraction analysis of clay
- Selective dissolution of clay minerals
- IR, DTA and SEM of clay minerals
- Identification and quantification of clay minerals

- Determination of surface charge of clay minerals
- Potentiometric titration of clay minerals.

References

- VELDEVELDEVELDE - Introduction to Clay Minerals
- LIMA R. WESLEY - Clays and Minerals
- MURRAY - Applied Clay Minerals
- ADA SWINEFORD - Clay and Clay minerals
- BRUCE VELDE - Origin and Mineralogy of Clay
- SPRINGER - The Origin of Clay Minerals in Soil and weathered rocks

SSC 609 RECENT TRENDS IN SOIL MICROBIAL BIODIVERSITY (2+1)

Objective

To acquaint students with respect to microbial evaluation and biodiversity, qualitative ecology of micro- organisms, nitrogen fixing micro – organisms, serology and molecular characterization and bio degradability.

Theory

Block I

Unit 1: Microbial evaluation and biodiversity, Microbial communities in ecosystems, New insights in below ground diverse of plant performance.

Unit 2: Qualitative ecology of microorganisms; Biomass and activities.

Unit 3: Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterizing N fixing microorganisms.

Block II

Unit 1: Serology and molecular characterization, ecological aspects of bio determination, soil waste and water management

Unit 2: Bio degradability, testing and monitoring of the bioremediation of pollutants and bacterial fertilizers.

Practicals

- Determination of soil microbes using classical techniques.
- Determination of soil microbial diversity using molecular techniques.
- Estimation of soil microbial biomass carbon, nitrogen and phosphorus.
- Estimation of key soil enzyme activities.
- Community level physiological profiling of microbial diversity.

References

- SPRINGER - Advances in Soil Microbiology, Resent Trends and future Prospects
- PRASADA BABU AND PARAMAGEETHAM CHINTHALA - Resent Trends in Microbial Diversity and Bio Prospecting
- ASHASINHA AND SEWETA SRIVASTAVA - Microbial Biodiversity
- ELSAS, JANSON AND TRERORS - Models Soil Microbiology