Syllabus

Post Graduate Programme
M.Sc. (Ag.) & Ph.D.

2022-23

SRI KARAN NARENDRA AGRICULRUE UNIVERSITY JOBNER
(JAIPUR)- 303329

Syllabus

Post Graduate Programme
M.Sc. (Ag.) & Ph.D.

FACULTY OF AGRICULTURE

2022-23

Compiled and Edited by
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(Professor of Plant Physiology)

Published by

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FOREWARD

The ICAR is striving hard to bring necessary reforms for quality assurance in agricultural education. The Council appointed National Core Group and BSMA committees for revision and restructuring of post-graduate and Doctoral syllabi in various disciplines of agriculture and allied sciences. It has been observed that a paradigm shift is necessary in academic regulations to comply with various provisions of national Education Policy-2020. As per recommendation of the New Education Policy-2020, the courses have been categorized as major and minor/ optional course. The NCG further constituted, 19 Broad Subject Matter Area (BSMA) committees to undertake this exercise in their respective subject matter domains. The present syllabus is an adoption of "New and restructured post graduate curricula & syllabi in agriculture as recommended by ICAR, New Delhi has been implemented in S.K.N. Agriculture University, Jobner from the academic session 2022-23. The revised curricula and syllabi contain lecture schedule for boththeory and practicals, list of relevant books for references, list of related journals and website for the benefit of students and teachers. I thank all Heads of the Departments and the members of the committee of the courses as well as dedicated teachers of the various Departments of SKN Agriculture University, Jobner for their valuable input and preparing of lecture schedule. The efforts of Dr. B. L. Jat, Dean and Faculty Chairman, SKN College of Agriculture, Jobner deserve appreciation for this timely action for publication of syllabi on behalf of the Sri Karan Narendra Agriculture University, Jobner. I compliment Dr. Sunita Gupta, Prof. Department of Plant Physiology and her team members Dr. D.K. Jajoria, Assoc. Prof. (Agronomy), Dr. G.L. Kumawat, Asstt. Prof. (Plant Pathology) and Dr. S.K. Goyal, Asstt. Prof. (Plant Pathology) for compiling and editing this valuable document which would prove useful for the teachers, students and the entire faculty of agriculture of SKNAU, Jobner.

Dated: **(Dr. Balraj Singh)**

Dr. B. L. Jat
Dean & Faculty
Chairman

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PREFACE

The country has undergone a major transformation with respect to higher education at post-graduate level in agriculture. The committee of experts comprising 19 Board Subject Matter Area revised the post-graduate (Master's and Doctoral) course curricula at country level in consultation with National Core Group constituted by the ICAR with various provision of New Education Policy 2020. The present compilation of syllabus for post-graduate level contains lecture schedules for theory and practical classes, reference books & journals and websites for each course. Dr. Sunita Gupta, Professor, Department of Plant Physiology and her team members namelyDr. D.K. Jajoria, Assoc. Prof. Agronomy, Dr. G.L. Kumawat, Asstt. Prof. Plant Pathology and Dr. S.K. Goyal, Asstt. Prof. Plant Pathology have done commendable exercise in compiling this important document. All the Heads of the S. K. N. Collage of Agriculture, Jobner also deserve appreciation for their co-operation and assistance in preparation of this syllabus in a book form.

Dated: **(B. L. Jat)**

CONTENTS

AGRICULTURAL ECONOMICS

Semester Wise Distribution of Courses

S. No	Course No.	Title of course	Credit Hrs.
M.Sc.(Ag.)Semester –I			
Major Courses			
1	**AGECON-511**	**MICRO ECONOMIC THEORY AND APPLICATIONS**	**3(3+0)**
2	**AGECON-512**	**AGRICULTURAL PRODUCTION ECONOMICS**	**2(1+1)**
3	**AGECON-513**	**AGRICULTURAL MARKETING AND PRICE ANALYSIS**	**3(2+1)**
Minor Courses			
4	**EXT-511**	**EXTENSION LANDSCAPE**	**2 (2+0)**
Supporting Courses			
5	**STAT-511**	**STATISTICAL METHOD FOR APPLIED SCIENCES**	**3(2+1)**
Common Courses			
6	**PGS-511**	**LIBRARYAND INFORMATION SERVICES**	**1(0+1)**
TOTAL			**14**
Semester –II			
Major Courses			
1	**AGECON-521**	**ECONOMETRICS**	**3(2+1)**
2	**AGECON-522**	**RESEARCH METHODOLOGY FOR SOCIAL SCIENCES**	**2(1+1)**
3	**AGECON-523**	**MACRO ECONOMICS AND POLICY**	**2(2+0)**
4	**AGECON-524**	**LINEAR PROGRAMMING**	**2(1+1)**
Minor Courses			
5	**EXT-523**	**CAPACITY DEVELOPMENT**	**3(2+1)**
Supporting Courses			
6	**STAT-525**	**MATHEMATICS FOR APPLIED SCIENCES**	**3(3+0)**
Total			**15**
Semester –III			
1	**AGECON-531**	**AGRICULTURAL FINANCE AND PROJECT MANAGEMENT**	**3(2+1)**
Minor Courses			
2	**EXT-531**	**EVALUATION AND IMPACT ASSESMENT**	**3(2+1)**
Common Courses			
3	**PGS- 531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**

4	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
7	**AGECON -543**	**RESEARCH**	**30**
Semester –IV			
1	**AGECON-541**	**SEMINAR**	**1**
2	**AGECON-542**	**COMPREHENSIVE**	**NC**
3	**AGECON-543**	**RESEARCH**	**30**

AGRICULTURAL ECONOMICS

M.Sc. (Ag.) Programme

AGECON511 MICRO ECONOMIC THEORY AND APPLICATIONS 3(3+0)

Objectives

The course envisages the concepts and principles embodying micro-economics. The economic problems, functioning of price mechanism, theory of household behavior and consumers demand function.

Theory

Block 1- Introduction to micro-economics

UNIT I: Basic concepts: A review

Scarcity and choice; production possibility frontier, Positive and normative economics; concepts of opportunity cost, Demand and Supply: determinants of individual demand/supply; demand/supply schedule and demand/supply curve; market versus individual demand/supply; shifts in the demand/supply curve.

Block 2- Insight of consumer, production and cost involved

Unit II: Consumer choice

Cardinal Utility Approach- Ordinal Utility Approach- Budget sets and preferences under different situations- Hicks and Slutsky income and substitution effects- Applications of Indifference curve approach- Revealed Preference Hypothesis- Consumer surplus- Derivation of demand curve- Elasticity of demand- Demand and supply together; how prices allocate resources; controls on prices- price floor and price ceiling-applications in agriculture.

Unit III; Production and Cost

Concept of economic cost ; Short run and long run cost curves; Increasing and decreasing cost industries; envelop curve; L- shaped cost curves; economies of scale; revenue and expenditure, elasticity and marginal revenue; firm equilibrium and profit.

Block 3- Overview of market

Unit IV; Market forms

Behavior of profit maximizing firms and production process- Perfect competition: Equilibrium of market. Long run industry supply, applications: Effects of taxes and subsidies: Monopoly: Equilibrium; Supply; Multiplant firm; Monopoly power; Deadweight loss; price discrimination; monopolistic competition: product differentiation; equilibrium of firm in the industry- with entry of new firms and with price competition. Comparison with pure competition. Duopoly: cournote model and reaction curves; Stackelberg's model, Bertrand model; Oligopoly

Unit V: Factor Markets

Labour and land markets- basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for labour; input demand curves shifts in input demand curves; competitive labour markets; economic rent and quasi rent.

Unit VI: Welfare Economics

Pareto Optimality, Social-welfare criteria, Social Welfare Economics

Lecture Schedule- Theory

S.No.	Topics	No. of Lectures
1.	Theory of consumer behavior	2
2.	Cardinal utility approach	2
3.	Ordinal utility approach	2
4.	Income effect	2
5.	Substitution effect	2
6.	Application and indifference curve	2
7.	Revealed preference hypothesis	2
8.	Consumer surplus	1
9.	Derivation of demand curve	1
10.	Elasticity of demand	1
11.	Production function	1
12.	Return to scale and economies of scale	1
13.	Technical progress	1
14.	Theory of cost	1
15.	Cost curve	2
16.	Profit maximization	2
17.	Cost minimization	1
18.	Derivation of supply curve	1
19.	Law of supply	1
20.	Production surplus	1
21.	Market equilibrium	1
22.	Behavior of the firms in competition markets	1
23.	Perfect competition	1
24.	Effect of taxation and subsidies	1
25.	Monopoly	1
26.	Monopolistic competition	2
27.	Oligopoly	2
28.	General equilibrium	2
29.	Welfare economics	2
30.	Pareto optionality	2
31.	Social welfare criteria, Social welfare functions	2
32.	Pareto Optimality, Social-welfare criteria, Social Welfare Economics	2
	Total	**48**

Suggested Readings:

1. *Modern Micro Economics by A. Koutsoyiannis, Published by Macmillan Press LTD*
2. *Micro Economic Theory by Ferguson and Gould by Richard D Erwin INC USA*
3. *Richard A.Bilas, Micro Economic Theory.*

4. *Leftwich Richard H. The Price System and Resources Allocation*
5. *Allen,C.L.,A Frame Work Economic Theory.*

AGECON512 AGRICULTURAL PRODUCTION ECONOMICS 2(1+1)

Objectives

To expose the students to develop the concept, significance and uses of production economics. To understand the relationships between factors and output.To learn how to decide the combination of inputs to be used as per the resources available. Ensure that the production process works efficiently.

Theory

Block 1- Introduction to Production Economics

Unit I – Concepts of production economics

Nature, scope and significance of agricultural production economics- Agricultural production processes, character and dimensions- spatial, temporal – Centrality of production functions, assumptions of production functions, commonly used forms-properties, limitations, specifications, estimation and interpretation of commonly used production functions.

Block 2- Factors and Costs

Unit II – Factors and theory of production

Factors of production, classification, interdependence, and factor substitution- determination of optimal levels of production and factor application – optimal factor combination and least cost combination of production – theory of product choice; selection of optimal product combination.

Unit III – Concepts of cost

Cost function and cost curves, components, and cost minimization – Duality theory – cost and production functions and its applications – Derivation of firm's input demand and output supply functions – Economies and diseconomies of scale.

Block 3- Assessment

Unit IV – Dynamics of economic assessment

Technology in agriculture production, nature and effects and measurements – Measuring efficiency in agricultural production; technical, allocative and economic efficiencies – Yield gap analysis- concepts- types and measurement – Nature and sources of risk, modeling and coping strategies.

Lecture Schedule- Theory

S. No.	Topics	No. of Lectures
1.	Nature, scope and significance of agriculture production economics Agricultural production processes, Assumptions of production functions	1
2.	Properties, limitations, specification, estimation and interpretation of commonly used production functions	5
3.	Factors of production, classification, interdependence, and factor substitution	1

4.	Determinations of optimal levels of production and factor application	1
5.	Optimal factor combination and least cost combination of production	1
6.	Theory of product choice; selection of optimal product combination	1
7.	Cost functions and cost curves, components of cost, Cost minimization	1
8.	Duality theory-cost and production functions and its applications – derivation of firm's input demand and output supply functions	1
9.	Technology in agricultural production, nature and effects and measurement, Economics and diseconomies of scale	1
10.	Measuring efficiency in agricultural production; technical allocative and economic efficiencies	1
11.	Yield gap analysis-concepts-types and measurement	1
12.	Nature and sources of risk	1
	Total	**16**

Practical

Different forms of production functions – specification, estimation and interpretation of production functions- returns to scale, factor shares, elasticity of production- physical optima- economic optima –least cost combination – optimal product choice – cost function estimation, interpretation- estimation of yield gap – incorporation of technology in production functions- measuring returns to scale – risk analysis.

Lecture Schedule- Practical

S. No.	Topics	No. of Lectures
1.	Different forms of production functions-specification, estimation and interpretation of production functions	5
2.	Measuring returns to scale	1
3.	Factor shares	1
4.	Elasticity of production	1
5.	Physical optima- economic optima	2
6.	Least cost combination	1
7.	Optimal product choice- cost function estimation and interpretation	2
8.	Estimation of yield gap	2
9.	Incorporation of technology in production functions	1
Total		**16**

Suggested Readings:

1. *E.O. Heady, Economics of Agricultural Production Economics: Theory with application.*
2. *John P. Doll and Frank Orazem, Production Economics: Theory with application*
3. *Heady E.O.& Dillon, J L.1961. Agriculture Production Functions. Kalyani Publishers, Ludhiana India.667 P.*
4. *Baumol,W.G. 1973. Economic theory and operations analysis. Practice Hall of India private limited, New Delhi. 626 P.*
5. *Gardner BL &Rausser GC. 2001. Handbook of Agricultural Economics Vol. I Agricultural Production. Elsevier.*

AGECON 513AGRICULTURAL MARKETING AND PRICE ANALYSIS3(2+1)

Objectives

The course is designed to acquaint the students about the basics of dynamics of agricultural marketing. The content includes supply, demand and marketing of farm production, marketing functions and channels, marketing costs, margins and efficiency, agricultural prices, new marketing formats like e-marketing, e- NAM, future trading, supply chain management, market intelligence etc.

Theory

Block 1- Introduction to Agricultural Marketing

Unit I – Introduction to agricultural marketing

New concepts in Agricultural Marketing- Characteristics of Agricultural product and production –Problems in Agricultural Marketing from Demand and Supply and Institutions sides.Market intermediaries and their role– need for regulation in the present context– Marketable and Marketed surplus estimation. Marketing Efficiency – Structure conduct and Performance Analysis – Vertical and Horizontal integration – Integration over space, time and form- Vertical coordination.

Block 2- Agricultural Markets

Units II – Aspects of agricultural marketing

Different form of marketing: Co-operative Marketing – APMC Regulated Marketing- Direct marketing, Farmer Producer Companies, e-NAM and marketing under e-NAM, e-marketing Contract farming and Retailing, organizing retailing -Supply Chain Management – State trading, Warehousing and other government agencies – Performance and Strategies- Market infrastructure needs, performance and government role- Value Chain Finance.

Unit III – Future marketing and government

Introduction to commodities markets and future trading – Basics of commodity futures- Operation Mechanism of commodity markets - price discovery – Hedging and Basis – Fundamental analysis – Technical Analysis – Role of government /SEBI in promoting commodity trading and regulatory measures.

Block 3- Advances in Agricultural Marketing

Unit IV – Use of Information Technology

Role of information technology and market intelligence in marketing of agricultural commodities, electronic auctions (e-bay), e-Chaupal, Agmarknet& Domestic and Export Market Intelligence Cell (DEMIC).

Unit V – Dynamics of prices

Price forecasting – time series analysis – time series models – spectral analysis.Price policy and economic development – non-price instruments.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	New concepts in agricultural marketing	1
2.	Characteristics of agricultural products and production	1
3.	Problems in agricultural marketing from demand and supply and institutions sides	1
4.	Market intermediaries and their role- need for regulation in present context	2
5.	Marketable and marketed surplus and their estimation	1
6.	Marketing efficiency – Structure, conduct and Performance analysis.	1
7.	Market integration and its types - Integration over space, time and form – Vertical coordination.	1
8.	Different forms of marketing - Marketing co-operatives - APMC regulated markets	2
9.	Direct marketing and Farmer Producer Companies	2
10.	e-NAM and marketing under e-NAM, e-marketing	1
11.	Contact farming and retailing, Organized retailing- Supply chain management–state trading	2
12.	Warehousing and other government agencies-performance and strategies	2
13.	Market infrastructure needs, performance and govt. role-value chain finance	2
14.	Introduction to commodities markets and future trading - Basics of commodity futures- operation mechanism of commodity markets	2
15.	Price discovery – hedging and basis-fundamental analysis-technical analysis	1
16.	Role of government/ SEB**I** in promoting commodity trading and regulatory measures	1
17.	Role of information technology and tele-communication in marketing of agricultural commodities, electronic-auctions (e-bay), e-Chaupals	2
18.	Agmarknet and Domestic and Export Market Intelligence-Cell	1

	(DEMIC),	
19.	Price forecasting – time series analysis – time series models – spectral analysis	4
20.	Price policy and economic development – non price instruments	2
Total		**32**

Practical

Supply and demand elasticity in relation to problems in agricultural marketing.Price spread and marketing efficiency analysis. Marketing structure analysis through concentration ratios. Performance analysis or Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products. Supply Chain Analysis – quantitative estimation of supply chain efficiency - Market Intelligence – characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports – commodity outlook – Technical analysis for important agricultural commodities – Fundamental Analysis for important agricultural commodities – Presentation of the survey results and wrap-up discussion.

Lecture Schedule- Practical

S.No.	Topics	No. of Lectures
1.	Supply and demand elasticity's in relation to problems in agricultural marketing	2
2.	Price spread and marketing efficiency analysis	2
3.	Marketing structure analysis through concentration ratios	2
4.	Performance analysis of regulated market and marketing societies	2
5.	Analysis on contact farming and Supply chain management of different agricultural commodities-milk and poultry product	2
6.	Chain analysis –quantitative estimation of supply chain efficiency - Market intelligence – characters, accessibility and availability price forecasting,	2
7.	Online searches for market information sources and interpretation of market intelligence reports – commodity outlook	2
8.	Technical analysis for important agricultural commodities – Fundamental analysis for important agricultural commodities – Presentation of the survey results and wrap-up discussion	2
Total		**16**

Suggested Readings:

1. *Acharya,S.S. &Agarawal, N.L.2004. Agricultural Marketing in India. Oxford and IBH Publishing company Pvt.Ltd. New Delhi.*
2. *Acharya, S.S. &Agarwal, N.L. 1994. Agricultural Prices- Analysis and Policy. Oxford IBH Publishing companyPvt.Ltd. New Delhi.*
3. *Richard H Kohls and Joseph N. Uhl: Marketing of Agricultural products by collier MacMillan International*.

AGECON521 ECONOMETRICS 3(2+1)

Objectives

The course provides knowledge of the econometrics methods like time series analysis, linear regression models and their application in economic analysis. The course provides an insight into the econometric problems in analyzing time series and cross section data.

Theory

Block 1- Introduction to Econometrics

Unit I – Introduction

Relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics- regression analysis.

Block 2- Classical Regression

Unit II – Classical Linear Regression

Basic two variable regression – assumption, estimation and interpretation- approaches to estimation – OLS and their properties – extensions to multi- variables models –multiple regression estimation and interpretation.

Unit III – Breaking down of classical assumptions

Violation of assumptions –identification, consequences and remedies for Multicollinearity, Heteroscedasticity, Autocorrelation– data problems and remedial approaches –model misspecification.

Block 3- Qualitative Variables

Unit IV – Qualitative variables and simultaneous equation models

Use of Dummy variables – introduction to simultaneous equations- identification problem.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Relationship between economic theory, mathematical economics, models and econometrics	2
2.	Methodology of econometrics	3
3.	Regression analysis, OLS Estimation, Interpretation	2
4.	BLUE Properties	2
5.	Classical Linear Regression Model	2
6.	Basic two variable regression, Estimation, Interpretation	2

7.	Multicollinearity, Causes, Detection, Consequences, Remedies	3
8.	Heteroscedasticity, Causes, Detection, Consequences, Remedies	3
9.	Auto correlation, Causes, Detection, Consequences, Remedies	3
10.	Specification Bias, Causes, Detection, Consequences, Remedies	3
11.	Use of dummy variables	3
12.	Simultaneous equation models	2
13.	Identification and approaches to estimation	2
Total		**32**

Practical

Single equation two variable model specification and estimation – hypothesis testing transformations of functional forms and OLS application – estimation of multiple regression model – hypothesis -testing and correcting specification errors – testing and managing Multicollinearity – estimation of regression with dummy variables. Testing heteroscedasticity and autocorrelation

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Single equation two variable model specification and estimation	2
2.	Hypothesis testing	2
3.	Transformation of functional forms and OLS application	2
4.	Estimation of multiple regression model	2
5.	Hypothesis testing	1
6.	Testing and correlation specification errors	1
7.	Testing and managing multicollinearity	1
8.	Testing and managing autocorrelation	1
9.	Testing and managing Heteroscedasticity	1
10.	Estimation of regression with dummy variables	1
11.	Estimation of regression with limited dependable linear variable	1
12.	Identification of equation in simultaneous equation system	1
Total		**16**

Suggested Readings:

1. *Dorfman R. 1996.Linear Programming and Economic Analysis. McGraw Hill.*
2. *Greene W.H. 2002.Econometric Analysis. Personal Education.*
3. *Johnston, J. and Dinardo, J.2000. Econometrics Methods. McGraw –Hill.*
4. *Koutseyianis, A. 1997. Theory of Econometrics. Barner& Noble.*
5. *Maddala, G.S. 2002. Econometrics. McGraw- Hill.*
6. *Pinndyck,R.S. and Rubinfeld, D.L. 1990. Econometric Models and Econometric Forecasts. McGraw Hill.*
7. *Basic econometrics – Damodar Gujrati , Dawn Porter , Sangeetha Gunasekar, McGraw-Hill Education Europe*

AGECON 522 RESEARCH METHODOLOGY FOR SOCIAL SCIENCES 2(1+1)

Objectives

The course deals with scientific methods of research, the initiation of an inquiry, formulation of research problems and hypothesis, the role of induction and deduction in research, collection and analysis of date and interpretation of results.

Theory

Block 1- Concepts of Research Methodology

Unit I - Concepts of research methodology

Importance and scope of research in agricultural economics.Types of research – Fundamental vs. Applied. Concept of researchable problem – research prioritization - selection of research problem. Approach to research – research process.

Block 2- Building up Hypothesis and sample selection

Unit II – Hypothesis: Framing and Testing

Hypothesis– Meaning- characteristics- types of hypothesis- review of literature- setting of course objective and hypotheses- testing of hypothesis.

Unit III Sampling

Sampling theory and sampling design – sampling error – methods of sampling – probability and non-probability sampling methods – criteria to choose. Project proposals – contents and scope – different types of projects to meet different needs – trade-off between scope and cost of the study. Research design and techniques-types of research design.

Block 3- Data Collection and Analysis

Unit IV Data Collection

Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed ended questions. Scaling Techniques. Preparation of schedule-problems in measurement of variables in agriculture.Interviewing techniques and field problems – methods of conducting survey – Reconnaissance and Pre testing.

Unit V Data Analysis

Data coding, tabulation, cleaning – Multivariate analysis – factor analysis 'PCA' cluster analysis. Universal procedures for preparation of bibliography – writing of research articles.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Meaning and types of research and approaches to research, importance and scope of research in agricultural economics	1
2.	Research process	1
3.	Concepts of researchable problem - Research prioritization – selection of research problem	1
4.	Hypothesis – meaning – characteristics and types of hypothesis	1
5.	Review of literature- setting of course objective and hypothesis – testing of hypothesis	1
6.	Sampling theory and sampling design-sampling error	1
7.	Methods of sampling – probability and non-probability sampling	1

	methods- criteria to choose	
8.	Project proposals – contents and scope – different types of projects to meet different needs – trade-off between scope and cost of the study	2
9.	Research design and techniques- type of research design	1
10.	Data collection – assessment of data needs – sources of data collection – discussion of different situations	1
11.	Mailed questionnaire and interview schedule - Structured, unstructured, open ended and closed ended question	1
12.	Scaling techniques	1
13.	Preparation of schedules - Problems in measurement of variables in agriculture	1
14.	Interviewing techniques and field problems - Methods of conducting survey - Reconnaissance survey and pretesting	1
15.	Data coding, tabulation, cleaning, Multivariate analysis – factor analysis, PCA, cluster analysis	2
16.	Universal procedure for preparation of bibliography - Writing of research articles	1
Total		**18**

Practical

Exercises in problem identification. Project proposals – contents and scope.Formulation of objective and hypothesis. Assessment of data needs – sources of data – methods of collection of data. Methods of sampling – criteria to choose – discussion on sampling under different situations. Scaling Techniques **–** measurement of scales. Preparation of interview schedule – Field testing. Method of conducting survey. Exercise on coding, editing, tabulation and validation of data. Preparing for data entry into computer. Hypothesis testing-parametric and non-parametric tests. Exercises on format for Thesis/ Report writing. Presentation of the results.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Exercise in problem identification Project proposals- contents and scope	2
2.	Formulation of objectives and hypothesis	1
3.	Assessment of data needs – sources of data- methods of collection of data	2
4.	Methods of sampling- criteria to choose – discussion on sampling under different situations	2
5.	Scaling Techniques – measurement of scales.	1
6.	Preparation of interview schedule – field testing	1
7.	Method of conducting survey	1
8.	Exercise on coding, editing, tabulation and validation of data	1

9.	Preparation of data entry into computer	1
10.	Hypothesis testing- parametric and non-parametric tests	1
11.	Exercise on format for thesis / report writing	2
12.	Presentation of the results	1
Total		**16**

Suggested Readings:

1. *Research Methodology in Agricultural Economics, Baker, C.B.*
2. *An Introduction to Logic and Scientific Method, Cohen, M.R. and Nagel, R.*
3. *The Theory of Enquiry, Devey, J. Logic*
4. *Social Sciences Research and Thesis Writing, Dhondhyal, S.P.*
5. *Correlation Analysis, Ezekiel, M.*
6. *Linear Programming Methods, Heady, E.O.*
7. *An Introduction to Scientific Research, Willson, E.R.*
8. *Research Methodology: A Survey, Anil Kumar Alts, New Delhi, 2008.*

AGECON523 MACRO ECONOMICS AND POLICY2(2+0)

Objectives

The course envisages the concepts and principles of macroeconomics from classical to Keynesian theories. The other component deals with the monetary system money, credit and banking system, value of money and economic activities, national income accounting and approaches to estimate national income theory of income and employment determination and inflation.

Theory

Block 1- Conceptualizing Macro Economics

Unit I – Introduction: Measurement and Concepts

Basic concepts and scope of Macro-economics, National Income Accounting: Methods of measurement of key macro- economic aggregates, relationship of measurement of national income and other aggregates (with numerical exercises),real and nominal income.

Block 2- Theories of Macroeconomics

Unit II –Classical Macroeconomics

Say's Law, Quantity theory of money, aggregate labour supply and demand of labour, classical theory of determining output, wages and prices.

Unit III – Income and Spending: Keynesian framework

Simple Keynesian model of income determination; Keynesian Multiplier- aggregate spending, taxation, transfer payments, foreign spending, balanced budget; budget surplus(with numerical exercises).

Block 3- Money, Consumption and inflation

Unit IV - Money, Interest and Income

Goods market equilibrium- IS curve; Demand for Money, the Liquidity Preference Theory – Liquidity trap; asset market equilibrium – LM curve; simultaneous equilibrium in goods and asset market – effect of fiscal and monetary policy.

Unit V – Theories of Aggregate Consumption and Investment

Absolute Income Hypothesis, Relative Income Hypothesis, Fisher's Inter-temporal Choice Model, Life-Cycle and Permanent Income Hypotheses; Profits and Accelerator Theory.

Unit VI – Inflation and Unemployment

Inflation: Nature, effects and control; Types of inflation – demand pull, cost push – stagflation, core inflation, hyperinflation; Phillips curve.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Basic concepts and scope of macro-economics	2
2.	National Income Accounting: - Methods of measurement of key macro-economic aggregates	2
3.	Relationship of national income and other aggregates (with numerical exercise), real and nominal income	1
4.	Say's law – classical theory	1
5.	Quantity theory of money – aggregate labour supply and demand of labour	3
6.	Classical theory of determining output, wages and prices	3
7.	Simple Keynesian model of income determination	2
8.	Keynesian multiplier – aggregate spending, taxation, transfer payments, balanced budget; budget surplus(with numerical exercise)	3
9.	Goods market equilibrium-IS curve – Demand for money, the liquidity preference theory – liquidity trap	3
10.	Asset market equilibrium-LM curve – simultaneous equilibrium in goods and asset market – effect of fiscal and monetary policy	3
11.	Absolute income hypothesis, relative income hypothesis, Fisher's inter-temporal choice model	3
12.	Life cycle and permanent income hypothesis, Profit and Accelerator theory	3
13.	Inflation: nature, effects and control; Types of inflation – demand pull, cost push – stagflation, core inflation, hyperinflation; Phillips curve	3
Total		**32**

Suggested Readings:

1. *Stonier &Hegue, A Text Book of Economic Theory*
2. *Samuelson, P.A. 1948. Foundation of Economic Analysis. Harvard University Press*

3. *M.C. Vaish, Allid, New Delhi, 1983 Macro – Economics Theory*
4. *Gardner Ackley, Macmillan, New York, 1961 Macro – Economics Theory*
5. *T.F. Dernburg& D. M. Madougali- Macro Economics*
6. *G. Sirkin – Introduction to Macro-Economic Theory*
7. *R.L. Heibroker-Understanding Macro-Economics*
8. *J.K Mehta- Macro Economics*
9. *Michael R. Pearce – The dictionary of modern Economics*.

AGECON 524 LINEAR PROGRAMMING 2(1+1)

Theory

Unit I

Decision making- concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulations of problems.

Unit II

Simplex Method: Concept of simplex Methods, solving profit maximization and cost minimization problems. Formulation of farms and non-farm problems as linear programming models and solutions.

Unit III

Extension of Linear Programming Models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

Unit IV

Game Theory – Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programming.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Decision making- concepts of decision making, Introduction to quantitative tools, Introduction to linear programming, Uses of LP in different fields	1
2.	Assumptions in LP, formulations of problems. Methods of finding out optimal solutions.	2
3.	Simplex Method: Concept of simplex Methods, solving profit maximization and cost minimization problems.	3
4.	Canonicocal form versus standard form of Linear programming	1
5.	Duality in Linear Programming, Reasons, Correspondence between primal and dual, Duality Theorems	2
6.	Extension of Linear Programming Models: Variable resource and price programming (Input-Output Analysis), Integer Programming, transportation problems, recursive programming, dynamic programming	4
7.	Problem of degeneracy	1

8.	Game Theory – Concepts of game theory, two person constant sum, zero sum game	1
9.	Saddle point, solution to mixed strategies, the rectangular game as Linear Programming.	1
Total		**16**

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method.Formulation of the simplex matrices for typical farm situations.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Formulation of Linear Programming Problems, Maximization and Minimization type, Graphical and algebraic	2
2.	Finding out Feasible and Optimum Solution of various problems through Graphical Method	2
3.	Solving of maximization and minimization problems by simplex method.	5
4.	Finding solution of a primal problem through its dual model using simplex	4
5.	Solution to the transportation problem	2
6.	Solving a game using pay-off matrix	1
Total		**16**

Suggested Readings:

1. *Dorfman R.1996. Linear programming and economic Analysis. McGraw Hill*
2. *Loomba N.P. 2006. Linear Programming. Tata McGraw Hill.*
3. *Shenoy G.1989. Linear Programming- Principles and Applications. Wiley Eastern Publications.*
4. *Vaserstein. 2006. Introduction to linear Programming. Pearson Education Publications.*

AGECON531 AGRICULTURAL FINANCE AND PROJECT MANAGEMENT3(2+1)

Objectives

This course is designed with an objective to deliver knowledge of the principles, procedures, problems and policies relating to financing agricultural firms. In addition to this, the students are also given knowledge about the research developments in the subjects. The approach is analytic.

Theory

Block 1-Introduction to Agricultural Finance

Unit I – Basic concepts: A Review

Role and importance of Agricultural Finance.Financial Institutions and credit flow to rural/priority sector. Agricultural lending's – Direct and Indirect Financing – Financing

through Co-operatives, NABARD and Commercial Banks and RRBs. Districts Credit Plans and lending to agriculture/priority sector. Micro-Financing and role of MFIs- NGO's and SHG's.

Block 2-Credit and Financial Analysis

Unit II – Credit and its aspects

Lending to farmers – the concept of 5 **C's**, 7 P's, and 3 R's of credit.Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals.Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

Unit III – Financial Analysis

Financial Decisions - Investment, Financing, Liquidity and Solvency. Preparation of financial statements– Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and assessing the performance of farm/firm.

Block 3- Project and Risk Management

Unit IV – Project Overview

Project approach in financing agriculture.Financial, economic and environmental appraisal of investment projects.Identification, preparation, appraisal, financing, and implementation of projects.Project appraisal techniques – undiscounted measures.Time value of money – use of discounted measures- B – C Ratio, NPV and IRR. Agreement, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Network Techniques – PERT and CPM.

Unit V –Risk and its Management

Risk in financing agriculture.Risk management strategies and coping mechanism. Crop Insurance Programmes – review of different crop insurance schemes – yield loss and weather-based insurance and their applications.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Role and importance of agricultural finance	1
2.	Financial institutions and credit flow to rural/priority sector	1
3.	Agricultural lending – direct and indirect financing	1
4.	Financing through co-operatives, NABARD	2
5.	Financing through commercial banks and RRBs	2
6.	District credit plan and lending to agriculture/priority sector	2
7.	Micro-financing and role of MFI's – NGO's and SHGs	1
8.	Lending to farmers – concept of 5 **C's,**7P's and 3 R's of credit	2
9.	Estimation of technical feasibility, economic viability and repaying capacity of borrowers	2
10.	Appraisal of credit proposals	1
11.	Understanding lenders and developing better working relationship and supervisory credit system	1
12.	Credit inclusions – credit widening and credit deepening	2
13.	Preparation of financial statements – balance sheet cash flow	2

	statement and profit and loss statement	
14.	Ratio analysis and assessing the performance of farm/firm	1
15.	Project approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementing of projects	2
16.	Project appraisal techniques- undiscounted measures	1
17.	Time value of money – use of discounted measures-B.C. ratio, NPV and IRR	2
18.	Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects	1
19.	Network techniques – PERT and CPM	2
20.	Risks in financing agriculture – risk management strategies and coping mechanism	1
21.	Crop insurance programmes – review of different crop insurance schemes – yield loss and weather based insurance and their applications	2
Total		**32**

Practical

Development of Rural Institutional Lending – Branch expansion, demand and supply of institutional agricultural credit and over dues and loan waiving-:An overview, rural Lending Programs of Commercial Banks, Lead Bank Scheme- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions, Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements, Performance of Micro financing institutions –NGO's and SHG's.Identification and formulation of investment projects, Project appraisal techniques – UndiscountedMeasures and their limitations, Project appraisal techniques –Discounted measures, Network Techniques - PERT and CPM for project management, Case Study Analysis of an Agricultural projects, Financial Risk and risk management strategies – crop insurance schemes, financial instruments and methods – E-banking, Kisan Card and core banking.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Development of rural lending – branch expansion, demand and supply of institutional agricultural credit and over dues and loan waiving:- An overview	1
2.	Rural lending programmes of commercial banks and co-operative lending institutions	1
3.	Lead bank scheme – Preparation of district credit plan	1

4.	Preparation of financial statements using farm/firm level data	1
5.	Farm credit appraisal techniques and farm financial analysis through financial statements	1
6.	Performance of micro-financing institutions- NGO's and self-help groups	2
7.	Identification and formulation of investment projects, Project appraisal techniques- undiscounted measures and their limitations	2
8.	Project appraisal techniques- discounted measures	2
9.	Network techniques- PERT and CPM for project management	2
10.	Case study analysis of an agricultural project	1
11.	Financial risk and risk management strategies – crop insurance schemes	1
12.	Financial instruments and methods- E-banking, Kisan credit cards and core banking	1
Total		**16**

Suggested Readings:

1. *E. Die Sollem, H. and Heady, E. O. (Ed.) Capital and Credit Need in Changing Agriculture, Bauman.*
2. *Hopkins,A. Barry, Peter Jo, and Baker,C.B.,Financial Management in Agriculture,*
3. *Willium G. Murray and Aaron G. Nelson, Iowa State University 1960 Agricultural Finance.*
4. *Agricultural Finance in India: Role of Commercial Banks, CharnjitChanona, Marketing and Economics Research Bureau,New Delhi, 1969.*
5. *Gittinger, J.P.1972. Economic analysis of agricultural projects, John Hopkins Univ. Press, Baltimore.*
6. *Little, I.M.D. and J.A. Mirrless 1974. Project appraisal and planning for developing countries, Oxford and IBH publishing Co. New Delhi.*
7. *Harberger,Arnold c 1972. Project Evaluation, collected papers, Macmillan.*
8. *Dr. U.K. Pandey, An Introduction to Agricultural Finance. Kalyani Publishers, New Delhi-Ludhiana.*
9. *S. Subba Reddy and P. Raghu Ram, Agricultural Finance and Management, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*

AGRICULTURAL EXTENSION EDUCATION

Semester Wise Distribution of Courses

S.No	Course No.	Title	Credit Hrs.
M.Sc.(Ag.) Semester-I			
1	EXT-511	EXTENSION LANDSCAPE	2(2+0)
2	EXT-512	APPLIED BEHAVIOR CHANGE	3(2+1)
3	EXT-513	ORGANIZATIONAL BEHAVIOR & DEVELOPMENT	3(2+1)
Minor Courses			
4	AGECON-512	AGRICULTURE PRODUCTION ECONOMICS	2(1+1)
Supporting Courses			
5	STAT-511	STATISTICAL METHOD FOR APPLIED SCIENCES	3(2+1)
Common Courses			
6	PGS-511	LIBRARY AND INFORMATION SERVICES	1(0+1)
Total			14
Semester-II			
1	EXT-521	RESEARCH METHODOLOGY IN EXTENSION	3(2+1)
2	EXT-522	ICTs FOR AGRICULTURAL EXTENSION & ADVISORY SERVICES	3(2+1)
3	EXT-523	CAPACITY DEVELOPMENT	3(2+1)
Minor Courses			
4	AGECON-521	ECONOMETRICS	3(2+1)
Supporting Courses			
5	STAT-522	BASIC SAMPLING TECHNIQUES	3(2+1)
Total			15
Semeser-III			
1	EXT-531*	EVALUATION AND IMPACT ASSESSMENT	3(2+1)
Minor Courses			
2	AGRON-531	AGRONOMY OF MAJOR CEREALS AND PULSES	3(2+1)
Common Courses			
3	PGS- 531	TECHNICAL WRITING AND COMMUNICATION SKILLS	1(0+1)
4	PGS-532	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1(1+0)

5	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
7	**EXT-543**	**RESEARCH**	**30**
Semester-IV			
1	**EXT541**	**MASTERS SEMINAR**	**1(0+1)**
2	**EXT-542**	**COMPREHENSIVE**	**NC**
3	**EXT-543**	**RESEARCH**	**30**

Ph.D. Agricultural Extension			
Semester-I			
1	**EXT-611**	**POLICY ENGAGEMENT AND EXTENSION**	**3(2+1)**
2	**EXT-612**	**METHODOLOGY FOR SOCIAL AND BEHAVIOURAL RESEARCH**	**3(2+1)**
Minor Courses			
3	**AGECON-513**	**AGRICULTURE MARKETING AND PRICE ANALYSIS**	**3(2+1)**
Supporting Courses			
4	**ENT-513**	**CONCEPTS OF INTEGRATED PEST MANAGEMENT**	**2 (2+0)**
Total			**11**
Semester-II			
1	**EXT-621***	**TECHNOLOGY COMMERSIALIZATION AND INCUBATION**	**3(2+1)**
2	**EXT-622***	**EDUCATIONAL TECHNOLOGY AND INSTITUTIONAL DESIGN**	**3(2+1)**
Minor Courses			
3	**AGRON-522**	**DRYLAND FARMING AND WATER SHED MANAGEMENT**	**3(2+1)**
Supporting Courses			
4	**STAT-524**	**APPLIED REGRESSION ANALYSIS**	**3(2+1)**
Total			**12**
Semester-III and onward			
1	**EXT-641**	**DOCTORAL SEMINAR-I**	**1(0+1)**
2	**EXT-642**	**DOCTORAL SEMINAR-II**	**1(0+1)**
3	**EXT-643**	**COMPREHENSIVE**	**NC**
4	**EXT-644**	**RESEARCH**	**75**

***Core Courses**

EXT- 511EXTENSION LANDSCAPE2(2+0)

Objective

The aim of this course is to introduce the new challenges before extension and how extension is evolving globally. It presents the new capacities that are needed by EAS providers to provide a much wider support tofarmers and it orient students to the new insights from communication and innovation studies that are influencing the practice of extension globally. The course alsohelps students to appreciate the process and the impact of extension reforms implemented in many countries.

Theory

BLOCK 1: GLOBALLY, WHAT IS NEW IN EXTENSION?

Unit 1: Challenges before Extension and Advisory Services (EAS)

Extension and Advisory Services (EAS)- Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals: Natural Resource Management- Supporting farmers to manage the declining/deteriorating water and soil for farming; Nutrition- Role of extension in supporting communities with growing nutritious crop and eating healthy food; Linking farmers to markets- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems; Supporting family farms- strengthening the capacities of family farms; Migration-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills; Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; Urban and peri-urban farming- How to support and address issues associated with urban and peri-urbanagriculture;Farmerdistress,suicides-Supportingfarmersintacklingfarmdistress

Unit 2: New Functions and New Capacities

Beyond transfer of technology: Performing new functions to deal with new challenges; Organising producers into groups-dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets; Mediating conflicts and building consensus to strengthen collective decision making; Facilitating access to credit, inputs and services-including development of service providers; Influencing policies to promote new knowledge at a scale Networking and partnership development including convening multi-stakeholder platforms/innovationplatforms. New Capacities needed by extension and advisory services at different levels –at the individual (lower, middle management and senior management levels), organizational and enabling environment levels; – Core competencies at the individual level;Varied mechanisms for capacity development (beyondtraining).

Unit 3: Pluralism in EAS

Pluralism in Extension Delivery: Role of private sector (input firms, agri-business companies,consultantfirmsandindividualconsultants)-Trendsinthedevelopmentof private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental organizations (National/international)/ Civil

Society Organizations (CSOs) in providing extension- Experiences from India and other countries; Producer Organizations- Role in strengthening demand and supply of extension services; their strength and weaknesses-experiences from different sectors.

BLOCK 2: INSIGHTS FROM INNOVATION STUDIES AND NEW EXTENSION APPROACHES

Unit 1: From the Linear Paradigm to Systems Paradigm

Diffusion of Innovations paradigm- strengths and limitations; multiple sources of innovation-farmer innovation, institutional innovation; farmer participation in technology generation and promotion; strength and limitations; Agricultural Knowledge and Information Systems (AKIS); strength and limitations; Agricultural Innovation Systems (AIS); Redefining Innovation- Role of Extension and Advisory Services in AIS-From information delivery to intermediation across multiple nodes; Role of brokering; Innovation Platforms, Innovation Management; Strength and weaknesses of AIS. Rethinking Communication in the Innovation Process – Network building, support social learning, dealing with dynamics of power and conflict.

Unit 2: Evolving Extension Approaches

Evolution and features of extension approaches: Transfer of technology approach; educational approach, farmer participatory extension approach, demand-driven extension, market led extension (value chain extension), extension for climate smart agriculture extension for entrepreneurship.

Extension systems in different regions: Asia-Pacific, Europe, Latin America, Australia, North America. Networking for Strengthening EAS: GFRAS (Global Forum for Rural Advisory Services) and its regionalnetworks

BLOCK 3: EXTENSION REFORMS AND POLICY CHALLENGES

Unit 1: Changes in Governance, Funding and Delivery

Reduction in public funding: public withdrawal from extension provision (partial/full); Examples/Cases; Privatization: Public funding and private delivery; cost sharing and cost recovery; Examples/Cases; Decentralisation of extension services; Examples/Cases; Lessons from extension reforms in different countries; Extension and Sustainable Development Goals(SDGs).

Unit 2: Challenges in Managing Pluralistic Extension Systems

Pluralism: Managing pluralism and Co-ordination of pluralistic extension provision; Public private partnerships in extension (including the role of local governments/panchayats and producer organisations); Examples, challenges in co-ordination; Achieving convergence in extension planning and delivery, Financing Extension: Mobilising resources for extension: public investments, donor support (grants/loans);

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	**Extension and Advisory Services (EAS)-** Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals: Natural Resource Management-Supporting farmers to manage the declining/deteriorating water and soil for farming;	2

2.	Nutrition- Role of extension in supporting communities with growing nutritious crop and eating healthy food; Linking farmers to markets- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems;	2
3.	Supporting family farms- strengthening the capacities of family farms; Migration-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills;	2
4.	Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; Urban and peri-urban farming- How to support and address issues associated with urban and peri- urbanagriculture;	1
5.	Farmerdistress,suicides-Supportingfarmersintacklingfarmdistress	1
6.	Beyond transfer of technology: Performing new functions to deal with new challenges; Organising producers into groups-dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets;	2
7.	Mediating conflicts and building consensus to strengthen collective decision making; Facilitating access to credit, inputs and services-including development of service providers;	1
8.	Influencing policies to promote new knowledge at a scale Networking and partnership development including convening multi-stakeholder platforms/innovationplatforms.	1
9.	New Capacities needed by extension and advisory services at different levels –at the individual (lower, middle management and senior management levels), organizational and enabling environment levels; –Core competencies at the individual level;	2
10.	Varied mechanisms for capacity development (beyondtraining)	1
11.	Pluralism in Extension Delivery: Role of private sector (input firms, agri-business companies,consultantfirmsandindividualconsultants)	1
12.	Trendsinthedevelopmentof private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental.	1
13.	Organizations (National/international)/ Civil Society Organizations (CSOs) in providing extension- Experiences from India and other countries;	1

14.	Producer Organizations- Role in strengthening demand and supply of extension services; their strength and weaknesses- experiences from different sectors;	1
15.	Diffusion of Innovations paradigm- strengths and limitations; multiple sources of innovation-farmer innovation, institutional innovation; farmer participation in technology generation and promotion; strength and limitations;	2
16.	Agricultural Knowledge and Information Systems (AKIS); strength and limitations; Agricultural Innovation Systems (AIS); Redefining Innovation- Role of Extension and Advisory Services in AIS-From information delivery to intermediation across multiple nodes;	2
17.	Role of brokering; Innovation Platforms, Innovation Management; Strength and weaknesses of AIS. Rethinking Communication in the Innovation Process – Network building, support social learning, dealing with dynamics of power and conflict.	1
18.	Evolution and features of extension approaches: Transfer of technology approach; educational approach, farmer participatory extension approach, demand-driven extension, market led extension (value chain extension), extension for climate smart agriculture extension for entrepreneurship.	2
19.	Extension systems in different regions: Asia-Pacific, Europe, Latin America, Australia, North America Networking for Strengthening EAS: GFRAS (Global Forum for Rural Advisory Services) and its regionalnetworks	1
20.	Reduction in public funding: public withdrawal from extension provision (partial/full); Examples/Cases; Privatization: Public funding and private delivery; cost sharing and cost recovery; Examples/Cases;	1
21.	Decentralisation of extension services; Examples/Cases; Lessons from extension reforms in different countries; Extension and Sustainable Development Goals(SDGs).	1
22.	Pluralism: Managing pluralism and Co-ordination of pluralistic extension provision;	1
23.	Public private partnerships in extension (including the role of local governments/panchayats and producer organisations); Examples, challenges in co-ordination; Achieving convergence in extension planning and delivery, Financing Extension: Mobilising resources for extension: public investments, donor support (grants/loans).	2
Total		**32**

Suggested Readings:

1. *Mandal S. 2004, Text Book of Agricultural Extension with Global Innovations.Kalyani Publishers*
2. *A.K. Singh, Lakhan Singh, R. Roy Burman, Dimensions of Agricultural Extension,Kalyani Publishers*
3. *ICAR, 2020 Handbook of Agriculture Extension.*
4. *Susan J. freauson 2018. Mapping the social Land Scape readings in sociology*
5. *Ashok G, Sharma P, Anisha S and Prerna T. 2018. Agriculture Extension System in India Review of Current Status, Trends and the Way Forward. Indian Council for Research on International Economic Relations (ICRIER). http://icrier.org/pdf/Agriculture-Extension-System-in-India-2018.pdf*
6. *Barber J, Mangnus E and Bitzer V. 2016. Harnessing ICT for agricultural extension. KIT Working Paper 2016:4. https://213ou636sh0ptphd141fqei1-wpengine.netdna-ssl.com/sed/wp-content/uploads/sites/2/2016/11/KIT_WP2016-4_Harnessing-ICT-for-agricultural-extension.pdf*
7. *Bingen RJ and Simpson BM. 2015. Farmer Organizations and Modernizing Extension and AdvisoryServices.MEASDiscussionPaper.http://meas.illinois.edu/wp-content/uploads/2015/04/Bingen-Simpson-2014-FarmerOrganizations-MEAS-Discussion-Paper.pdf*
8. *Bitzer V, Wongtschowski M, Hani M and Blum M. 2016. New directions for inclusive Pluralistic Service Systems. In New Directions for Inclusive Pluralistic Service Systems Rome (Italy). FAO.http://www.fao.org/3/a-i6104e.pdf*
9. *Burton ES & Kristin D. 2014. Status of Agricultural Extension and Rural Advisory Services Worldwide. GFRAS: Lindau, Switzerland. http://www.g-fras.org/en/knowledge/gfras-publications.html?download=391:status-of-agricultural-extension-and-rural-advisory-services-worldwide*
10. *Christoplos I. 2010. Mobilizing the potential of rural and agricultural extension. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/012/i1444e/i1444e.pdf*
11. *David S. 2018. Migration and rural advisory services. GFRAS Issues Paper 2. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/knowledge/gfras-publications/category/97-gfras-issues-papers.html?download=856:migration-and-rural-advisory-services*
12. *GFRAS. 2015. Producer organisations in rural advisory services: Evidence and experiences. Position Paper. Lindau: Global Forum for Rural Advisory Services. http://www.g-fras.org/en/593-producer-organisations-in-rural-advisory-servicesevidence-and-experiences.html*
13. *GFRAS. 2016. Five Key Areas for Mobilising the Potential of Rural Advisory Services. GFRAS Brief 1. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/knowledge/gfras-publications.html?download=4:five-key-areas-for-mobilising-the-potential-of-rural-advisory-services*

14. *GFRAS.2016. The New Extensionist Learning Kit. http://g-fras.org/en/knowledge/new-extensionist-learningkit-nelk.html#module-1-introduction-to-the-new-extensionist*
15. *GRFAS. 2014. Policy Compendium. http://www.g-fras.org/en/policy-compendium.html*
16. *Gwyn EJ and Garforth C. nd. The history, development, and future of agricultural extension. FAO. Rome. http://www.fao.org/docrep/W5830E/w5830e03.htm*
17. *Jennings JR, Packham RG and Woodside D. 2011. Shaping change: natural resource management, agriculture and the role of extension. Australasia Pacific Extension Network.http://www.apen.org.au/shaping-change*
18. *Leeuwis C with A W van den Ban. 2004. Communication for rural innovation: Rethinking agricultural extension. John Wiley &Sons.*
19. *Manfre C, Rubin D and Nordehn C. 2017. Assessing How Agricultural Technologies can Change Gender Dynamics and Food Security Outcomes. A three part toolkit. Integrating Gender and Nutrition within Agricultural Extension Services(INGENAES).http://www.culturalpractice.com/wpcontent/uploads/Introduction-to-the-Toolkit-Final-10_17.pdf*
20. *Mittal N, Sulaiman RV and Prasad RM. 2016. Assessing capacity needs of Extension and Advisory Services: A Guide for Facilitators. Agricultural Extension in South Asia (AESA). http://crispindia.org/wpcontent/uploads/2015/09/Facilitators-Guide-Final-LR.pdf*
21. *Rajalahti R, Janssen W and Pehu E. 2008. Agricultural innovation systems: From diagnostics toward operational practices. Agriculture & Rural DevelopmentDepartment,*
22. *Saravanan R and Suchiradipta B. 2015. mExtension – Mobile Phones for Agricultural Advisory Services. Note 17. Gfras good practice note for extension and advisory services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/mextension.html#SNote17*
23. *Saravanan R, Suchiradipta B, Meera SN, Kathiresan C and Anandaraja N. 2015. Web Portals for Agricultural Extension and Advisory Services. Note 16. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.https://www.g-fras.org/en/good-practice-notes/16-web-portals-for-agricultural-extension-and-advisory-services.html#SNote8*
24. *Saravanan R, Sulaiman RV, Davis K and Suchiradipta B. 2015. Navigating ICTs for Extension and Advisory Services. Note 11. GFRAS Good Practice Notes for Extension andAdvisoryServices.GFRAS:Lindau,Switzerland. https://agrilinks.org/sites/default/files/resource/files/gfras-ggp-note11_navigating_icts_for_ras_1.pdf*
25. *Sulaiman RV 2015. Agricultural Innovation Systems. Note 13. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/agricultural-innovation-systems.html#SNote8*

26. *Sulaiman RV and Davis K. 2012. The New Extensionist: Roles, strategies, and capacities to strengthen extension and advisory services. In Lindau, Switzerland: Global Forum for Rural Advisory Services.http://www.g-fras.org/en/157-thenew-extensionist*
27. *Suvedi M and Kaplowitz MD. 2016. What Every Extension Worker Should Know: Core Competency Handbook. Michigan State University. Department of Community Sustainability. https://agrilinks.org/library/what-every-extensionworker-should-know-core-competency-handbook*
28. *Swanson BE and Rajalahti R. 2010. Strengthening Agricultural Extension and Advisory Systems: Procedures for Assessing. Transforming, and Evaluating Extension Systems. Agriculture and Rural Development Discussion Paper; No. 45. World Bank, Washington,DC.©WorldBank. http://siteresources.worldbank.org/INTARD/Resources/Stren_combined_web.pdf*
29. *Swanson BE. 2008. Global Review of Good Agricultural Extension and Advisory Service Practices. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/pdf/011/i0261e/i0261e00.pdf*
30. *Terblanche S and H Ngwenya. 2017. Professionalisation of Rural Advisory Services. Note*
31. *World Bank. 2006. Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/7184*

WEBSITES

*1.**AESA-Agricultural Extension in South Asia http://www.aesanetwork.org/***

2 . FAO -Food and Agricultural Organisation (Research and Extension)

http://www.fao.org/research-and-extension/en/

3.GFRAS- Global Forum for Rural Advisory Services http://www.g-fras.org/en/

4. INGENEAS-Integrating Gender and Nutrition within Agricultural Extension Services

https://ingenaes.illinois.edu/

5.IFPRI-International Food Policy Research Institute (Extension)

http://www.ifpri.org/topic/agricultural-extension

6.KIT- Royal Tropical Institute (KIT)-Sustainable Economic Development https://www.kit.nl/sed/WUR-Wageningen University and Research Research (Knowledge, Technology and Innovation Group (KTI))

7.https://www.wur.nl/en/Research-Results/Chair-groups/Social-Sciences/KnowledgeTechnology-and-Innovation-Group.htm

EXT-512 APPLIED BEHAVIOUR CHANGE3(2+1)

Objective

This course aims to build capacities of students to understand the fundamental psychological processes which guide human behaviour at individual, group and community levels in specific contexts, to develop sound extension strategies.

Theory

BLOCK 1: FOUNDATIONS OF BEHAVIOUR CHANGE

Unit 1: Foundations of Human Behaviour

Human behaviour – Meaning, importance and factors influencing human behaviour; Individual variations – intelligence, ability and creativity– foundations and theories, personality and temperament - foundations, approaches, theories of personality, measuring personality (traits, locus of control, self-efficacy; Personal, social and moral development – meaning, concepts – self-concept, self-esteem and self-worth and theories. Motivation – foundations, approaches, theories, managing human needs and motivations; perceiving others – impression, attitude, opinions; Emotions - foundations, types and functions, measuring emotionalintelligence

BLOCK 2: COGNITIVE PROCESSES AND LEARNING

Unit 1: Cognitive Processes affecting Human Behaviour

Sensory organs and their role cognition; Cognitive processes – Attention, perception, remembering and forgetting, knowledge and expertise – meaning and theoriesPrinciples and processes of perception; Consciousness – meaning, types, sleep and dreams; Learning and Memory – Memory - meaning, types and mechanisms of storage and retrieval of memories in the Human brain; Complex cognitive processes - Concept formation, Thinking, Problem solving and transfer – foundations, theories andapproaches.

Unit 2: Information Processing

Information processing – meaning, principles; Models of information processing - Waugh and Norman model of primary and secondary memory; Atkinson and Shiffrin's stage model of memory; other models including blooms taxonomy and Sternberg's Information Processing Approach;

Unit 3: Learning

Learning – foundations, approaches and theories; Cognitive approaches of learning – meaning, principles theories and models; Memory – foundations, types; Behavioural approaches of learning – foundations and theories - classical conditioning, operant conditioning, applied behaviour analysis; Social cognitive and constructivist approaches to learning – foundations and theories – social cognitive theory, Self-regulated learning; learning styles – meaning, types and applications in learning

Unit 4: Judgment, Choice and Decision-making

Human judgement – meaning, nature, randomness of situations, theories and models;Choice – meaning, criteria for evaluating options; theories and models of humanchoice; Choice architecture; Decision-making – Meaning, problem analysis; steps and techniques of decision-making under different contexts.

BLOCK 3: HUMAN BEHAVIOUR IN THE SOCIETY

Unit 1: Attitudes and Influence

Attitudes - meaning, assumptions, types, theories and models of attitude formation; methods of changing attitudes,relating to others - liking, attraction, helping behavior, prejudice, discrimination and aggression; Liking / affect – meaning, types and theories; Attraction – meaning, types and theories; Persuasion – meaning, theories and techniques; Social influence and groups – conformity, compliance andobedience

Unit 2: Social Judgment, Social Identity and Inter-Group Relations

Social judgment – meaning, frame of reference, stereotyping; The judgement of attitude models; Attribution – meaning, theories; Rational decision making; Social identify – meaning, types; assessment; Groups – meaning, types, group processes; sustainability of groups; Inter group processes and theories sociallearning.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Human behaviour – Meaning, importance and factors influencing human behaviour;	1
2.	Individual variations – intelligence, ability and creativity– foundations and theories, personality and temperament - foundations, approaches, theories of personality, measuring personality (traits, locus of control, self-efficacy;	2
3.	Personal, social and moral development – meaning, concepts – self-concept, self-esteem and self-worth and theories.	1
4.	Motivation – foundations, approaches, theories, managing human needs and motivations; perceiving others – impression, attitude, opinions; Emotions - foundations, types and functions, measuring emotionalintelligence.	2
5.	Sensory organs and their role cognition; Cognitive processes – Attention, perception, remembering and forgetting, knowledge and expertise – meaning and theoriesPrinciples and processes of perception;	2
6.	Consciousness – meaning, types, sleep and dreams; Learning and Memory – Memory - meaning, types and mechanisms of storage and retrieval of memories in the Human brain;	2
7.	Complex cognitive processes - Concept formation, Thinking, Problem solving and transfer – foundations, theories andapproaches.	2
8.	Information processing – meaning, principles; Models of information processing - Waugh and Norman model of primary and secondary memory;	2
9.	Atkinson and Shiffrin’s stage model of memory; other models including blooms taxonomy and Sternberg’s Information Processing Approach;	2
10.	Learning – foundations, approaches and theories; Cognitive approaches of learning – meaning, principles theories and models;	1

11.	Memory – foundations, types; Behavioural approaches of learning – foundations and theories - classical conditioning, operant conditioning, applied behaviour analysis;	2
12.	Social cognitive and constructivist approaches to learning – foundations and theories – social cognitive theory, Self-regulated learning; learning styles – meaning, types and applications in learning.	2
13.	Human judgement – meaning, nature, randomnessof situations, theoriesand models;	1
14.	Choice – meaning, criteria for evaluating options; theories and models of humanchoice; Choice architecture;	1
15.	Decision-making – Meaning, problem analysis; steps and techniques of decision-making under different contexts.	1
16.	Attitudes - meaning, assumptions, types, theories and models of attitude formation; methods of changing attitudes,relating to others - liking, attraction, helping behavior, prejudice, discrimination and aggression;	2
17.	Liking / affect – meaning, types and theories; Attraction – meaning, types and theories;	1
18.	Persuasion – meaning, theories and techniques; Social influence and groups – conformity, compliance andobedience.	1
19.	Social judgment – meaning, frame of reference, stereotyping; The judgement of attitude models;	1
20.	Attribution – meaning, theories; Rational decision making; Social identify – meaning, types; assessment;	1
21.	Groups – meaning, types, group processes; sustainability of groups; Inter group processes and theories sociallearning.	2
Total		**32**

Practical

1. Understanding perception – Attentional Blink and Repetition Blindnessexercise
2. Understanding attention - Testing selective attention capacity and skills and processing speed ability through Strooptest
3. Hands-on experience in the techniques for assessing creative thinking – divergent and convergentthinking
4. Lab exercise in applying Maslow's need hierarchy to assessmotivation
5. Learning - Classical conditioning and operantconditioning
6. Assessing learning styles through Barsch and Kolbinventories
7. Practical experience in buildingself-esteem
8. Assessment of emotionalintelligence
9. Exercises in problemsolving

10. Exercises in visualperception
11. Measuring self-concept using psychometrictools
12. Experiment on factors influencing informationprocessing
13. Assessment ofattitudes
14. Handsonexperienceinmethodsofpersuasion
15. Fieldexperienceinassessingsocialjudgement
16. Simulation exercise to understand decision-making under differentsituations
17. Exercise in rationaldecision-making.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Understanding perception – Attentional Blink and Repetition Blindness exercise.	1
2.	Understanding attention - Testing selective attention capacity and skills and processing speed ability through Stroop test.	1
3.	Hands-on experience in the techniques for assessing creative thinking – divergent and convergent thinking.	1
4.	Lab exercise in applying Maslow's need hierarchy to assess motivation.	1
5.	Learning - Classical conditioning and operant conditioning.	1
6.	Assessing learning styles through Barsch and Kolb inventories.	1
7.	Practical experience in building self-esteem.	1
8.	Assessment of emotional intelligence.	1
9.	Exercises in problem solving, Exercises in visual perception.	1
10.	Measuring self-concept using psychometric tools.	1
11.	Experiment on factors influencing information processing.	1
12.	Assessment of attitudes.	1
13.	Hands on experience in methods of persuasion.	1
14.	Field experience in assessing social judgement.	1
15.	Simulation exercise to understand decision-making under different situations.	1
16.	Exercise in rational decision-making.	1
Total		**16**

Suggested Readings

1. *Parvesh Saini,2028 Behavioral Sciences (Psychology and sociology), Lotus Publication*
2. *Eiser J, Richard. 2022. Social Psychology: Attitudes, Cognition and Social Behaviour. Cambridge: Cambridge University Press.*
3. *Eysenck MW and Keane M T. 2020.Cognitive psychology: A student's handbook. Sixth Edition, Hove: Psychology Press.*
4. *Feldman RS. 2008. Essentials of understanding psychology (7th ed.). Boston: McGraw- Hill. Gilovich T, Keltner D, and Nisbett RE. 2022. Social psychology. New York: W.W. Norton & Co.*

5. *Moreno R. 2020.Educational Psychology. Hoboken, NJ: John Wiley & Sons Inc.*
6. *Nevid JS. 2022. Essentials of psychology: Concepts and applications Belmont, CA: Wadsworth, Cengage Learning.*
7. *Rachlin H. 2989. Judgment, decision, and choice: A cognitive/behavioural synthesis. New York: W.H. Freeman*

EXT-513 ORGANISATIONAL BEHAVIOR AND DEVELOPMENT 3(2+1)

Objectives

- To understand the theory and practice relating to the processes of organizational behavior, development andchange.
- To develop insight and competence in diagnostic and intervention processes and skills for initiating and facilitating change inorganizations.
- To gain necessary self-insight, skills in facilitation, organizational development (OD) skills, group process and techniques, to become an effective change agents and OD consultants.
- To understand the behavior of individuals and small groups in organization with special focus on beliefs, attitudes and values, human inference - attribution, self-concept, motivation, active listening, interpersonal communication, conflicts management.

Theory

BLOCK 1: ORGANIZATIONAL BEHAVIOR

Unit 1: Basics of Organization

Introduction to organizations-concept and characteristics of organizations; Typology of organizations; Theories of organizations: nature of organizational theory, Classical theories, Modern management theories, System Theory - Criticisms and lessons learnt/analysis.

Unit 2: Basics of Organizational Behaviour

Concepts of Organisational Behaviour, Scope, Importance, Models of Organisational Behaviour**.**

Unit 3: Individual Behaviour in Organizations

Introduction, Self-awareness, Attribution, Learning, Systems approach to studying organization needs and motives – attitude, values and ethical behavior, Personality, Managing motivation in organizations.

Unit 4: Group Behaviour in Organization

Foundations of group, group behaviour and group dynamics, Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations; Teams in Organizations-Team building experiential exercises, Interpersonal Communication and Group; Power and Influence, managing Conflict and Negotiation skills, Job/ stress management, problem-solving techniques

Unit 5: Productive Behaviour and Occupational Stress

Productive behaviour - Meaning, dimension; Job analysis and Job performance – meaning, dimensions, determinants and measurement; Job satisfaction and organizational commitment - meaning, dimensions and measures, roles and role clarity; Occupational stress- meaning,

sources, theories and models, effects, coping mechanism, effects and management; Occupational stress in farming, farmer groups/ organizations, research and extension organizations.

Unit 6: Organizational System

Organizations Structure- Need and Types, Line & staff, functional, committee, project structure organizations, centralization &decentralization, Different stages of growth and designing the organizational structure; Organizational Design-Parameters of Organizational Design, Organization and Environment, Organizational Strategy, Organization and Technology, Power and Conflicts in Organizations, Organizational Decision-Making; Organizational Culture vs Climate; Organizational Change; Organizational Learning and Transformation.

BLOCK 2: ORGANISATIONAL DEVELOPMENT

Unit 1: Overview of Organizational Development

Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values.

Unit 2: Managing the Organizational Development Process

Basic Component of OD Program-Diagnosis-contracting and diagnosing the problem, Diagnostic models, open systems, individual level group level and organizational level diagnosis; Action-collection and analysis for diagnostic information, feeding back the diagnosed information and interventions; Program Management- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.

Unit 3: Organizational Development Interventions

Meaning, Importance, Characteristics of Organization development Interventions, Classification of OD Interventions-Interpersonal interventions, Team Interventions, Structural Interventions, Comprehensive Interventions.

Unit 4: Organizational Development Practitioner or Consultant

Who is OD consultant? Types of OD consultants and their advantages, qualifications, Comparison of traditional consultants Vs. OD consultants, Organizational Development process by the practitioners' skills and activities.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Introduction to organizations-concept and characteristics of organizations; Typology of organizations;	1
2.	Theories of organizations: nature of organizational theory, Classical theories, Modern management theories, System Theory - Criticisms and lessons learnt/analysis.	2
3.	Concepts of Organisational Behaviour, Scope, Importance, Models of Organisational Behaviour.	2

4.	Introduction, Self-awareness, Attribution, Learning, Systems approach to studying organization needs and motives – attitude, values and ethical behavior, Personality, Managing motivation in organizations.	2
5.	Foundations of group, group behaviour and group dynamics, Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations;	2
6.	Teams in Organizations-Team building experiential exercises, Interpersonal Communication and Group; Power and Influence, managing Conflict and Negotiation skills, Job/ stress management, problem-solving techniques.	2
7.	Productive behaviour - Meaning, dimension; Job analysis and Job performance – meaning, dimensions, determinants and measurement; Job satisfaction and organizational commitment - meaning, dimensions and measures, roles and role clarity;	2
8.	Occupational stress- meaning, sources, theories and models, effects, coping mechanism, effects and management;	2
9.	Occupational stress in farming, farmer groups/ organizations, research and extension organizations.	1
10.	Organizations Structure- Need and Types, Line & staff, functional, committee, project structure organizations, centralization &decentralization, Different stages of growth and designing the organizational structure;	2
11.	Organizational Design-Parameters of Organizational Design, Organization and Environment, Organizational Strategy, Organization and Technology, Power and Conflicts in Organizations, Organizational Decision-Making; Organizational Culture vs Climate;	2
12.	Organizational Change; Organizational Learning and Transformation.	2
13.	Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values.	2
14.	Basic Component of OD Program-Diagnosis-contracting and diagnosing the problem, Diagnostic models, open systems, individual level group level and organizational level diagnosis;	2
15.	Action-collection and analysis for diagnostic information, feeding back the diagnosed information and interventions;	2
16.	Program Management- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.	2
17.	Meaning, Importance, Characteristics of Organization	2

	development Interventions, Classification of OD Interventions-Interpersonal interventions, Team Interventions, Structural Interventions, Comprehensive Interventions.	
18.	Who is OD consultant? Types of OD consultants and their advantages, qualifications, Comparison of traditional consultants Vs. OD consultants, Organizational Development process by the practitioners' skills and activities.	2
Total		**32**

Practical

1. Case Analysis of organization in terms of process – attitudes and values, motivation, leadership
2. Simulation exercises on problem-solving – study of organizational climate in different organizations.
3. Study of organizational structure of development departments, study of departmentalization, span of control, delegation of authority, decision-making patterns.
4. Study of individual and group behaviour at work in an organization.
5. Conflicts and their management in an organization.
6. Comparative study of functional and non-functional organizations and drawing factors for organizational effectiveness.

Exercise on OD interventions (Interpersonal, Team, Structural, Comprehensive) with its procedure to conduct in an organization

Lecture Schedule- Practical

S.No.	Topics	No. of Lectures
1.	Case Analysis of organization in terms of process – attitudes and values, motivation, leadership.	2
2.	Simulation exercises on problem-solving – study of organizational climate in different organizations.	2
3.	Study of organizational structure of development departments, study of departmentalization, span of control, delegation of authority, decision-making patterns.	3
4.	Study of individual and group behaviour at work in an organization	2
5.	Conflicts and their management in an organization.	2
6.	Comparative study of functional and non-functional organizations and drawing factors for organizational effectiveness.	3
7.	Exercise on OD interventions (Interpersonal, Team, Structural, Comprehensive) with its procedure to conduct in an organization	2
Total		**16**

Suggested Readings

1. *Gupta C.B. A textbook of organizational behavior. S. Chand and Co. Ltd*
2. *Dr.InderJeet and Dr.SumanSolanki 2017.Organization Behavioural, TAXMANN'S*
3. *Wendell L. French, Ceci H. Bell and Jr. veenaVohra Organizational development.*
4. *Bhattacharyya DK. 2011. Organizational Change and Development, Oxford University Press.*
5. *Hellriegel D, Sloccum JW and Woodman. 2001. Organizational Behaviour. Cincinnati, Ohio: South-Western College Pub.*
6. *Luthans F. 2002. Organizational Behaviour. Tata McGraw-Hill, New York*
7. *Newstrom JW and Davis K. 2002. Organizational Behaviour: Human behaviour at Work. Tata-McGraw Hill, New Delhi.*
8. *Peter MS. 1998. The Fifth Discipline: The Art and Practice of Learning Organization. Random House, London.*
9. *Pradip NK. 1992. Organizational Designs for Excellence.Tata McGraw Hill, New Delhi.*
10. *Shukla, Madhukar. 1996. Understanding Organizations. Prentice Hall of India, New Delhi.*
11. *Stephens PR and Timothy AJ. 2006. Organizational Behaviour, 12th Edition. Prentice Hall Pub.*
12. *Thomas GC and Christopher GW. 2013. Organizational development and change, 10th edition, South-Western college publishing.*
13. *Wendell LF and Cecil HB. 1999. Organizational Development: Behavioural science interventions for organization improvement, Pearson. 368*

EXT-521 RESEARCH METHODOLOGY IN EXTENSION 3(2+1)

Objective

This course aimed to create a workforce which has sound fundamental knowledge and critical competencies in planning, conducting and applying behavioural research for developing quality extension models, methods andtools.

Theory

BLOCK 1: INTRODUCTION TO BEHAVIOURAL RESEARCH

Unit 1: Nature of Behavioural Research

Methods of knowing; Science and scientific method; Behavioural research – Concept, aim, goals and objectives; Characteristics and Paradigms of research; Types of behavioural research based on applications, objectives and inquiry; Types of knowledge generated through research – historical, axiological, theoretical and conceptual knowledge, prior research studies, Role of behavioural research in extension; Careers in behaviouralresearch.

Unit 2: The Behavioural Research Process

Basic steps in behavioural research – Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools; Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.

BLOCK 2: STEPS IN BEHAVIOURAL RESEARCH PROCESS

Unit 1: Formulating a Research Problem

The research problem and research topic - definitions; Importance of formulating a research problem; Sources of research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem; Strategies for writing research problem statement; Research purpose statement; Research questions – Types , Criteria for selecting research questions, techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging theobjectives.

Unit 2: Reviewing the Literature

Review-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical; Literature review for quantitative and qualitative studies; Steps in conducting literature review – Identify key terms, locate literature,criticalevaluationandselection;organizingliteratureandwritingliteraturereview.

Unit 3: Identifying Variables and Hypotheses

Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research; Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; Techniques of identifying concepts, constructs and variables - Types of concepts; Types of variables –causal relationship, the study design; and the unit of measurement; Hypotheses. Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval and ratio; Criteria for choosing measurement levels forvariables.

Unit 4: Formulating Research Designs, Methods and Tools

Research designs – Definition, purpose and functions; Research Design as Variance Control MAXMINCON Principle; Criteria for selecting a suitable Research Design; Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis; Qualitative designs - ethnographic, grounded theory, phenomenological and Narrative research; Mixed method designs – Action research design; Translational research; Elements of research design - Research strategies, Extent of researcher interference, Study setting, Unit of analysis and Time horizon. Sources of errors while specifying research designs. Internal and external validity; Choosing right research design; Triangulation - Importance in behavioural research, Types of triangulations. Research methods: Designing research Instruments – questionnaires, interview schedules; tests – knowledge tests, behaviour performance tests; scales – scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory ruralappraisal.

Unit 5: Selecting Sample

Sampling - population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample; Types of sampling - Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; Non-probability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling;

Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; Generalization– Importance, Types ofgeneralizations.

Unit 6: Collecting Data

The process of collecting data – Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection. Testing goodness of measures through item analysis - Reliability and validity; Types of validity – Content validity: Face and content validity, Criterion-related validity: concurrent and predictive validity, Construct validity: convergent, and discriminant validity,factorial validity, and nomological validity; Types of reliability – Test-Retest, Parallel forms, Inter- item consistency reliability, Split-half reliability. Factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitativeresearch.

Unit 7: Analyzing and Interpreting the Data

Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses; Parametric analysis – Descriptive and inferential statistics, Hypothesis testing - Type I and Type II errors. Concepts in hypothesis testing, P Value; Multivariate data analysis – regression, factor analysis, cluster analysis, logistic regression and structural equation modelling. Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; Methods of interpreting data and drawing inferences - The Ladder of Inference; Methods of communicating and displaying analysed data.

Unit 8: Reporting and Evaluating Research

Writing reports and research publications; Evaluation Methodology.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Methods of knowing; Science and scientific method; Behavioural research – Concept, aim, goals and objectives;	1
2.	Characteristics and Paradigms of research; Types of behavioural research based on applications, objectives and inquiry;	1
3.	Types of knowledge generated through research – historical, axiological, theoretical and conceptual knowledge, prior research studies, Role of behavioural research in extension; Careers in behaviouralresearch.	1
4.	Basic steps in behavioural research – Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools;	1
5.	Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.	1
6.	The research problem and research topic - definitions; Importance of formulating a research problem; Sources of	1

	research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem;	
7.	Strategies for writing research problem statement; Research purpose statement; Research questions – Types, Criteria for selecting research questions, techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging theobjectives.	1
8.	Review-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical; Literature review for quantitative and qualitative studies;	1
9.	Steps in conducting literature review – Identify key terms, locate literature,criticalevaluationandselection;organizingliteratureand writingliteraturereview.	1
10.	Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research;	1
11.	Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; Techniques of identifying concepts, constructs and variables - Types of concepts; Types of variables –causal relationship, the study design; and the unit of measurement;	2
12.	Hypotheses. Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval and ratio; Criteria for choosing measurement levels forvariables.	1
13.	Research designs – Definition, purpose and functions; Research Design as Variance Control MAXMINCON Principle; Criteria for selecting a suitable Research Design; Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis;	2
14.	Qualitative designs - ethnographic, grounded theory, phenomenological and Narrative research; Mixed method designs – Action research design; Translational research; Elements of research design - Research strategies, Extent of researcher interference, Study setting, Unit of analysis and Time horizon. Sources of errors while specifying research designs.	2
15.	Internal and external validity; Choosing right research design;	1

	Triangulation - Importance in behavioural research, Types of triangulations.	
16.	Research methods: Designing research Instruments – questionnaires, interview schedules; tests – knowledge tests, behaviour performance tests; scales – scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory ruralappraisal.	2
17.	Sampling - population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample;	1
18.	Types of sampling - Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; Non-probability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling;	2
19.	Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; Generalization– Importance, Types ofgeneralizations.	1
20.	The process of collecting data – Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection.	1
21.	Testing goodness of measures through item analysis - Reliability and validity; Types of validity – Content validity: Face and content validity, Criterion-related validity: concurrent and predictive validity, Construct validity: convergent, and discriminant validity,factorial validity, and nomological validity;	1
22.	Types of reliability – Test-Retest, Parallel forms, Inter- item consistency reliability, Split-half reliability. Factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitativeresearch.	1
23.	Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses;	1
24.	Parametric analysis – Descriptive and inferential statistics, Hypothesis testing - Type I and Type II errors. Concepts in hypothesis testing, P Value; Multivariate data analysis – regression, factor analysis, cluster analysis, logistic regression and structural equation modelling.	2
25.	Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; Methods of interpreting	1

	data and drawing inferences - The Ladder of Inference; Methods of communicating and displaying analysed data.	
26.	Writing reports and research publications; Evaluation Methodology.	1
Total		**32**

Practical

1. Selecting a research problem and writing problemstatement.
2. Narrowing down research problem to purpose, research questions and objectives.
3. Choosing, evaluating and reviewing researchliterature.
4. Selection of variables through construct conceptualization and definingvariables.
5. Choosing research design based on researchproblem.
6. Choosing right sampling method and estimating samplesize.
7. Developing research methods and tools – questionnaires, interview schedule, check lists and focus groupguides.
8. Writing a researchproposal.
9. Fielddatacollectionusingresearchmethodsandtools.
10. Testingreliabilityandvalidityofresearchinstruments.
11. Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives ofresearch.
12. Writing report, writing of thesis and researcharticles.
13. Presentation ofreports.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Selecting a research problem and writing problem statement.	1
2.	Narrowing down research problem to purpose, research questions and objectives.	2
3.	Choosing, evaluating and reviewing researchliterature.	1
4.	Selection of variables through construct conceptualization and defining variables.	1
5.	Choosing research design based on research problem.	1
6.	Choosing right sampling method and estimating sample size.	1
7.	Developing research methods and tools – questionnaires, interview schedule, check lists and focus group guides.	2
8.	Writing a research proposal.	1
9.	Field data collection using research methods and tools.	1
10.	Testing reliability and validity of research instruments.	1
11.	Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives of research.	2
12.	Writing report, writing of thesis and research articles.	1
13.	Presentation of reports.	1

Total	**16**

Suggested Readings

1. *Kothari C.R. Research Methodology methods and techniques*
2. *Ray G.L. and SagarMandal Research Methods in social science and extension education*
3. *P. Dalvadeenam and L. L. SomaniResearch methodology in extension education*
4. *Dilip Kumar dangi, K.s. KadianMotilalmeena Research methodology in extension education*
5. *Wilkinson T.S. and Bhandarkar P.C. Methodology and techniques of social science.*
6. *Babbie E. 2008. The basics of social research. 4th ed. Belmont, CA, USA; Thompson Wordsworth.*
7. *Creswell JW. 2009. Research design: Qualitative, quantitative, and mixed methods approaches. Third edition. Thousand Oaks: SagePublications.*
8. *Creswell JW. 2012. Educational research: Planning, conducting, and evaluating quantitative and qualitative research. Fourth edition. Boston, MA: Pearson.*
9. *Kerlinger FN and Lee HB. 2000. Foundations of Behavioral Research. Orlando, FL: Harcourt CollegePublishers.*
10. *Kumar R. 2014. Research Methodology: A Step--by--Step Guide for Beginners. Fourth.Edition. Thousand Oaks, California: Sage Publications.*
11. *Malhotra NK. 2010. Marketing research: An applied orientation. Sixth Edition. Upper Saddle River, NJ: Prentice Hall.*
12. *NeumanWL. 2006. Social Research Methods: Qualitative and Quantitative Approaches.*
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EXT-522ICTS FOR AGRICULTURAL EXTENSION AND ADVISORY SERVICES 3(2+1)

Objectives

To discuss different ICT initiatives, knowledge management process and application aspects

To orient students on advances in smart/ disruptive technologies and data analytics Hands on experience in navigating ICTs.

Theory

BLOCK 1: INTRODUCTION TO INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs) & E-EXTENSION

Unit 1: ICTs- Concepts and Status

ICTs- meaning, concepts, basics of ICTs, global and national status, types, tools and functions of ICTs, innovations, meaning of e-Governance, e-learning, m-Learning, advantages and limitations of ICTs.

Unit 2: ICTs in Knowledge Management

Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.

Unit 3: e-Extension initiatives in Agriculture and allied sectors

e-Extension, overview of Global and national e-extension initiatives, Inventory of e- Extension initiatives in Agriculture from Central and Rajasthan governments, ICAR, SAUs, private sector and NGO initiatives inIndia.

BLOCK 2: APPLICATION OF ICTs IN EXTENSION AND ADVISORY SERVICES

Unit 1: ICT Applications

Knowledge centers (telecenters), digital kiosks, websites and web portals, community radio, farmers call centers, mobile phone based advisory services and mobile applications (mExtension), Self-learning CDs on Package of practices, social media, digital videos, Market Intelligence and Information Systems- ICT enabled Supply-Chains & Value-Chains/ e-Marketing (e-NAM, Agmarknet etc.

Unit 2: ICT Expert Systems

Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Weather,etc.

Unit 3: ICT Networks

Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Course CERA, EduEx, etc.), e-Governance Systems; digital networks among extension personnel / SHGs/ FarmersGroups.

BLOCK 3: KNOWLEDGE MANAGEMENT AND STANDARDS

Unit 1: Policies in Knowledge Management

Global policy/ Standards on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source etc; Language Technology Applications; National e-Agriculture policy/ Strategies/ guidelines.

Unit 2: Web Standards

Web standards, creating and writing for web portals, development of mobile applications, developing digital videos- story board- video recording- video editing, types of blogs and writingguidelines.

Unit 3: Social Media Applications to engage audience

Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data-analytics.

BLOCK 4: SMART & DISRUPTIVE TECHNOLOGIES AND ADVANCED ANALYTICS FOR AGRICULTURAL EXTENSION

Unit 1: Smart Technologies

Open technology computing facilities, System for data analytics/ mining/ modelling/ Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies- Analysis; Internet of Things (IoTs), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.

Unit 2: Human Computer Interactions

Human Computer Interactions-Meaning; Theories of multimedia learning - Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning; Basic Principles of Multimedia Learning - Split-attention, Modality, Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment; Learner control, animation, collaboration, prior knowledge, and working memory.Interactive design-Meaning, importance; Approaches of interactive design - user-centered design, activity-centered design, systems design, and genius design; Methods of interactive design - Usability testingmethods.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	ICTs- meaning, concepts, basics of ICTs, global and national status, types, tools and functions of ICTs, innovations, meaning of e-Governance, e-learning, m-Learning, advantages and limitations of ICTs.	2
2.	Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.	1
3.	e-Extension, overview of Global and national e-extension initiatives, Inventory of e- Extension initiatives in Agriculture from Central and Rajasthan governments, ICAR, SAUs, private sector and NGO initiatives inIndia.	3
4.	Knowledge centers (telecenters), digital kiosks, websites and web portals, community radio, farmers call centers, mobile phone based advisory services and mobile applications (m Extension), Self-learning CDs on Package of practices, social media, digital videos.	3
5.	Market Intelligence and Information Systems- ICT enabled Supply-Chains & Value-Chains/ e- Marketing (e-NAM, Agmarknet etc.)	1
6.	Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Weather,etc.	2
7.	Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Course CERA, Edu Ex, etc.), e-Governance	3

	Systems; digital networks among extension personnel / SHGs/ FarmersGroups.	
8.	Global policy/ Standards on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source etc; Language Technology Applications; National e-Agriculture policy/ Strategies/ guidelines.	2
9.	Web standards, creating and writing for web portals, development of mobile applications, developing digital videos-story board- video recording- video editing, types of blogs and writingguidelines.	2
10.	Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data- analytics.	2
11.	Open technology computing facilities, System for data analytics/ mining/ modelling/ Development of Agricultural simulations;	1
12.	Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies- Analysis;	1
13.	Internet of Things (IoTs), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.	1
14.	Human Computer Interactions-Meaning; Theories of multimedia learning - Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning;	2
15.	Basic Principles of Multimedia Learning - Split-attention, Modality, Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment; Learner control, animation, collaboration, prior knowledge, and working memory.	3
16.	Interactive design-Meaning, importance; Approaches of interactive design - user-centered design, activity-centered design, systems design, and genius design;	2
17.	Methods of interactive design - Usability testingmethods.	1
Total		**32**

Practical

1. Content and client engagementanalysis.
2. Designing extension content forICTs.
3. Creating and designing web portals, blogs, social mediapages.
4. Developing digitalvideos.
5. Live streaming extension programmes and organizingwebinars.

6. Working with Farmers callcentres.
7. Engaging with professional digitalnetworks.

Writing for digitalmedia

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Content and client engagement analysis	2
2.	Designing extension content for ICTs	2
3.	Creating and designing web portals, blogs, social media pages	2
4.	Developing digital videos	2
5.	Live streaming extension programmes and organizing webinars	2
6.	Working with Farmers call centres	2
7.	Engaging with professional digital networks	2
8.	Writing for digital media	2
Total		**16**

Suggested Readings

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WEBSITES

1. FAO -Food and Agricultural Organisation (Research and Extension) http://www.fao.org/research-and-extension/en/

2. CTA-The Technical Centre for Agricultural and Rural Cooperation: Digitalization https://www.cta.int/en/channel/digitalisation-sid05951b8c7-e611-4f34-9ae6-8c0fc0c822bc

3. GFRAS- Global Forum for Rural Advisory Services http://www.g-fras.org/en/

4. AESA-Agricultural Extension in South Asia http://www.aesanetwork.org/

EXT-523 CAPACITY DEVELOPMENT 3(2+1)

Objectives

- To understand the concepts of training, capacity building, capacity development and human resource development in the context of roles and responsibilities of extension professionals
- To discuss capacity development- approaches, strategies, needs assessment and methods /tolls
- To help you devise, organize, implement and evaluate capacity development programmes

Theory

BLOCK 1: INTRODUCTION TO CAPACITY DEVELOPMENT

Unit 1: Capacity Development- An Overview

Training, capacity building, capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types and levels of capacities - Institutional capacities, Organisational capacities Individual capacities. Types of capacity building - Based on structure (structured, semi-structured &unstructured), Based on context (orientation, induction and refresher), and other categories (online, Webinar, distance etc.). Components of capacity development; Capacity development cycle.

Unit 2: Capacity Development- Approaches and Strategies

Capacity Development Dilemma- Theory versus Practice, Trainee versus Task, Structured versus Unstructured, Generic and Specific; Approaches in Capacity Development - Informative approach, Participatory approach, Experimental approach/ Experiential, Performance based approach; Capacity Development Strategies - Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy.

Unit 3: Planning and Organization of Capacity Development Programmes

Steps in Designing and Planning of Capacity Development- Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design,Step7. Prepare evaluation form, Step 8. Determine follow-up activities;

BLOCK 2: CAPACITY DEVELOPMENT NEEDS ASSESSMENT

Unit 1: Planning and Organization of Capacity Development Programmes

Concept of Need Assessment; Approaches in Need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.

Unit 2: Capacity Development Needs Assessment Methods

Data Collection Methods in Identifying Needs - Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group Discussion, Interview, SWOT Analysis); Information and Skills required in Need Analysis;

Identification of Needs through Task Analysis - Task identification, Task Analysis, GapAnalysis.

BLOCK 3: CAPACITY DEVELOPMENT INSTITUTIONS AND MANAGEMENT

Unit 1: Capacity Development Institutions

Capacity Developer (Trainer): Meaning and concept; Types of Capacity Developers (regular, ad-hoc, part time, guest and consultants); Roles of Capacity Developer (explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/interpreter, change agent); Good Capacity Developer – Qualities, skills and roles Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator); Capacity Development Centres and Locations; Organisation's Role in CapacityDevelopment.

Unit 2: Capacity Development Project Formulation

Project Proposal: Concept and Meaning; Steps in Project Formulation- Review of past proposals, Consulting experts, consultants, and previous organizers, Review past project evaluation reports, Interact with the prospective beneficiaries;

BLOCK 4: CAPACITY DEVELOPMENT PROCESS AND HRD

Unit 1: Capacity Development Methods and Tools

Capacity Development Methods –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T - group / Laboratory methods; Factors Determining Selection of Methods - Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; Capacity DevelopmentAids.

Unit 2: Evaluation

Capacity Development Programme Evaluation - Meaning & Importance; Purpose of Evaluation; Principles of Evaluation; Types of Evaluation – Formative, Summative, Kirkpatrick's four levels of evaluation; Process of Evaluation- Evaluation at the beginning, Evaluation during the programme, Evaluation at the end; Use of evaluation findings; Statistical Tools for evaluation.

Unit 3: Human Resource Development

HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession) Work system , Development system, Components of HRD System - Performance Appraisal, Potential Appraisal, Task System, Development System, Socialization System, Governance; Functions of HRD-Organizational Development, Career Development.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Training, capacity building, capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types and levels of capacities - Institutional capacities, Organisational capacities Individual capacities.	2
2.	Types of capacity building - Based on structure (structured, semi-structured &unstructured), Based on context (orientation,	2

	induction and refresher), and other categories (online, Webinar, distance etc.). Components of capacity development; Capacity development cycle.	
3.	Capacity Development Dilemma- Theory versus Practice, Trainee versus Task, Structured versus Unstructured, Generic and Specific; Approaches in Capacity Development - Informative approach, Participatory approach, Experimental approach/ Experiential, Performance based approach;	2
4.	Capacity Development Strategies - Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy.	2
5.	Steps in Designing and Planning of Capacity Development- Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design,Step7. Prepare evaluation form, Step 8. Determine follow-up activities;	2
6.	Concept of Need Assessment; Approaches in Need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.	1
7.	Data Collection Methods in Identifying Needs - Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group Discussion, Interview, SWOT Analysis);	2
8.	Information and Skills required in Need Analysis; Identification of Needs through Task Analysis - Task identification, Task Analysis, GapAnalysis.	2
9.	Capacity Developer (Trainer): Meaning and concept; Types of Capacity Developers (regular, ad-hoc, part time, guest and consultants);	1
10.	Roles of Capacity Developer (explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/interpreter, change agent);	1
11.	Good Capacity Developer – Qualities, skills and roles Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator);	2
12.	Capacity Development Centres and Locations; Organisation's	1

	Role in CapacityDevelopment	
13.	Project Proposal: Concept and Meaning; Steps in Project Formulation- Review of past proposals, Consulting experts, consultants, and previous organizers, Review past project evaluation reports, Interact with the prospective beneficiaries;	2
14.	Capacity Development Methods –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T - group / Laboratory methods;	1
15.	Factors Determining Selection of Methods - Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; Capacity DevelopmentAids.	2
16.	Capacity Development Programme Evaluation - Meaning & Importance; Purpose of Evaluation; Principles of Evaluation; Types of Evaluation – Formative, Summative, Kirkpatrick's four levels of evaluation;	2
17.	Process of Evaluation- Evaluation at the beginning, Evaluation during the programme, Evaluation at the end; Use of evaluation findings; Statistical Tools for evaluation.	1
18.	HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession,Work system,Development system.	2
19.	Components of HRD System - Performance Appraisal, Potential Appraisal, Task System, Development System, Socialization System, Governance; Functions of HRD-Organizational Development, Career Development.	2
Total		**32**

Practical

1. Capacity development needs assessment exercise
2. Capacity development project formulation exercise
3. Planning organizing and conducting an extension capacity development programme
4. Designing a programme
5. Writing learning objectives
6. Developing objectives into curriculumTraining plan
7. Organizing capacity development workshop
8. Evaluation with pre & post training tests

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Capacity development needs assessment exercise	2

2.	Capacity development project formulation exercise	2
3.	Planning organizing and conducting an extension capacity development programme	2
4.	Designing a programme	2
5.	Writing learning objectives	2
6.	Developing objectives into curriculum	2
7.	Training plan	1
8.	Organizing capacity development workshop	2
9.	Evaluation with pre & post training tests	1
Total		**16**

Suggested Readings

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WEBSITES

*1.**TAP- Tropical Agriculture Platform for Capacity Development***

https://www.tapipedia.org/

*2.**FAO Capacity Development** **http://www.fao.org/capacity-development/en/***

3. GFRAS- Global Forum for Rural Advisory Services http://www.g-fras.org/en/

4. AESA-Agricultural Extension in South Asia http://www.aesanetwork.org/

EXT-531 EVALUATION AND IMPACT ASSESMENT3 (2+1)

Objectives

- To orient students on the importance of evaluation and impactassessment
- To develop capacities for evaluation and impactassessment
- Discuss ways of conducting evaluations and impact assessment The course is organized asfollows

Theory

BLOCK 1: PROGRAMME EVALUATION

Unit 1: Introduction to Evaluation

Concept of Evaluation: Meaning and definitions Why Evaluation is Done and When? Programme planning, analyses programme effectiveness, decision making, accountability, impact assessment, Objectives criteria and approaches of programme evaluation, the context of program evaluation in agricultural extension; Role and Credibility of Evaluator: Role as educator, facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator.

Unit 2: Evaluation Theories

Evaluation theory vs. practice –Evaluation theories - Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory (other theories / approaches - Utilization-Focused Evaluation & Utilization-Focused Evaluation (U-FE), Checklist, Values Engaged Evaluation, Empowerment Evaluation, Theory-Driven Evaluation). Integration between theory and practice of evaluation: –evaluation forums, workshops, conferences and apprenticeship /internship.

BLOCK 2: EVALUATION PROCESS

Unit 1: How to Conduct Evaluation

Ten Steps in programme evaluation: (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, on-going, wrap-up, follow-up) and type of evaluation study needed (needs assessment, baseline, formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques (8) Collect, analyze and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types, reporting results, reporting tips, reporting negative findings (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programmestakeholders).

BLOCK 3: PROGRAMME MANAGEMENT TECHNIQUES

Unit 1: SWOT Analysis and Bar Charts

SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool; Conducting SWOT Analysis - Common Questions in SWOT Analysis; Advantages and Disadvantages of SWOT; Bar Charts (Gantt Charts and Milestone Charts) - Characteristics, advantages andlimitations.

Unit 2: Networks

Networks – Introduction, origin and widely used networks (Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages. Networks Terminology – Activity, Dummy activity, Event (predecessor event, successor event, burst event, merge event, critical event), Earliest Start Time (EST), Latest Start Time (LST), Critical Path, Critical Activity, Optimistic time (O_T), Pessimistic time (P_O), Most likely time (T_M), Expected time (T_E), Float or Slack, Event Slack, Lead time, Lag time, Fast tracking, Crashing critical path, Acclivity Table, Danglers, Normal Time. Rules for Preparation of Networks and Steps in Network Preparation withexample

BLOCK 4: PROGRAMME EVALUATION TOOLS

Unit 1: Bennett's Hierarchy of Evaluation

Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy – Inputs, activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy

Unit 2: Logic Framework Approach (LFA)

Introduction to LFA – Background and description; Variations of LFA - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP); LFA Four-by- Four Grid – Rows from bottom to top (Activities, Outputs, Purpose and Goal & Columns representing types of information about the events (Narrative description, Objectively Verifiable Indicators (OVIs) of these events taking place, Means of Verification (MoV) Advantages and Disadvantages ofLFA.

BLOCK 5: IMPACT ASSESSMENT

Unit 1: Introduction to Impact Assessment Concept of Impact Assessment: Meaning, concept and purpose in different contexts; Impact Assessment Framework: Meaning of inputs,

outputs, outcomes, impacts and their relation with monitoring, evaluation and impactassessment.

Unit 2: Impact Assessment Indicators

Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services - social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessmentindicators.

Unit 3: Approaches for Impact Assessment

Impact assessment approaches – Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, Non-experimental). Econometric Impact Assessment: - (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Adoption Quotient etc).Qualitative and Participatory Impact Assessment Methods.

Unit 4: Environment Impact Assessment (EIA)

Concept of EIA – Introduction, what it is? Who does it? Why it is conducted? How it is done? Benefits and important aspects of EIA-risk assessment, environmental management and post product monitoring.~~;~~ Salient Features of 2006 Amendment to EIA Notification - Environmental Clearance/Rejection, participants of EIA; Shortcomings of EIA and How to improve EIAprocess?

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Concept of Evaluation: Meaning and definitions concept in different contexts; Why Evaluation is Done and When?	1
2.	Programme planning, analyse programme effectiveness, decision making, accountability, impact assessment, policy advocacy	1
3.	Objectives, types, criteria and approaches of programme evaluation, evaluation principles; the context of program evaluation in agricultural extension	1
4.	Role and Credibility of Evaluator: Role as educator, facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator	1
5.	Evaluation theory vs. practice – synergistic role between practice and theory in evaluation	1
6.	Evaluation theories - Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory (other theories / approaches - Utilization-Focused	1
7.	Integration between theory and practice of evaluation: – evaluation forums, workshops, conferences and apprenticeship / internship	1

8.	Ten Steps in programme evaluation: (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, on-going, wrap-up, follow-up) and type of evaluation study needed (needs assessment, baseline, formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques (8) Collect, analyze and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types, reporting results, reporting tips, reporting negative findings (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programme stakeholders)	2
9.	SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool; Conducting SWOT Analysis - Common Questions in SWOT Analysis; Advantages and Disadvantages of SWOT; Bar Charts (Gantt Charts and Milestone Charts) - Characteristics, advantages and limitations	2
10.	Networks – Introduction, origin and widely used networks (Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages	2
11.	Networks Terminology – Activity, Dummy activity, Event (predecessor event, successor event, burst event, merge event, critical event), Earliest Start Time (EST), Latest Start Time (LST), Critical Path, Critical Activity, Optimistic time (To), Pessimistic time (Po), Most likely time (TM), Expected time (TE), Float or Slack, Event Slack, Lead time, Lag time, Fast tracking, Crashing critical path, Acclivity Table, Danglers, Normal Time.	2
12.	Rules for Preparation of Networks and Steps in Network Preparation with example	1
13.	Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy – Inputs, activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy	2

14.	Introduction to LFA – Background and description; Variations of LFA - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP); LFA Four-by- Four Grid – Rows from bottom to top (Activities, Outputs, Purpose and Goal & Columns representing types of information about the events (Narrative description, Objectively Verifiable Indicators (OVIs) of these events taking place, Means of Verification (MoV) Advantages and Disadvantages of LFA	2
15.	Meaning, concept and purpose in different contexts; Impact Assessment Framework: Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment. Meaning, concept and purpose in different contexts;	2
16.	Impact Assessment Framework: Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.	1
17.	Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services - social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.	1
18.	Impact assessment approaches – Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, non experimental).	2
19.	Econometric Impact Assessment: - (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Adoption Quotient etc). Qualitative and Participatory Impact Assessment Methods	2
20.	Concept of EIA – Introduction, what it is? Who does it? Why it is conducted? How it is done? Benefits and important aspects of EIA-risk assessment, environmental management and post product monitoring	2
21.	Salient Features of 2006 Amendment to EIA Notification - Environmental Clearance/Rejection, participants of EIA; Shortcomings of EIA and How to improve EIA process?	2
Total		**32**

Practical

1. Search the literature using web / printed resources and identify evaluation indicators for thefollowing:

- Utilization-FocusedEvaluation
- Values EngagedEvaluation
- EmpowermentEvaluation
- Theory-DrivenEvaluation

2. Visit Directorate of Extension in your university and enquire about extension programmes being implemented / coordinated by Directorate. Develop an evaluation proposal of any one programme using 'Ten Steps in Programme Evaluation' discussed in the theoryclass.
3. Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the 'Evaluating the Evaluation'approach.
4. Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOTgrid.
5. Identify an on-going development programme and make-out 6 activities from the programme.
   Draw a Gantt chart for 12 months programme activities.
6. Write a report on evaluation hierarchy levels and indicators as per Bennett's hierarchy of evaluation for any development programme orproject.
7. Develop LFA four-by-four grid for any development programme or project with activities, outputs, purpose & goal and objectively verifiable indicators, means of verification &assumptions.
8. Visit a nearby KVKs / ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK / ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessmentindicators.
9. Refer any Environment Impact Assessment report and analyse steps in EIA. Write yourobservations.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Search the literature using web / printed resources and identify evaluation indicators for the following: - Utilization-Focused Evaluation, Values Engaged Evaluation 30, Empowerment Evaluation, Theory-Driven Evaluation	2
2.	Visit Directorate of Extension in your university and enquire about extension programmes being implemented / coordinated by Directorate. Develop an evaluation proposal of any one programme using 'Ten Steps in Programme Evaluation'	2

	discussed in the theory class.	
3.	Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the 'Evaluating the Evaluation' approach.	1
4.	Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOT grid.	2
5.	Identify an on-going development programme and make-out 6 activities from the programme. Draw a Gantt chart for 12 months programme activities.	2
6.	Write a report on evaluation hierarchy levels and indicators as per Bennett's hierarchy of evaluation for any development programme or project.	2
7.	Develop LFA four-by-four grid for any development programme or project with activities, outputs, purpose & goal and objectively verifiable indicators, means of verification & assumptions.	2
8.	Visit a nearby KVKs / ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK / ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.	2
9.	Refer any Environment Impact Assessment report and analyse steps in EIA. Write your observations.	1
Total		**16**

Suggested Readings

1. *Ajitkumar Roy Evaluation and impact of technology and development activity in agricultural fisheries and allied fields.*
2. *J S Yadav Evaluation of Agricultural Extension*
3. *Jessica Dart Review of Evaluation in Agricultural Extension*
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5. *Adrienne M, Gundel S, Apenteng E and Pound B. 2011. Review of Literature on Evaluation Methods Relevant to Extension. Lindau, Switzerland: Global Forum for Rural Advisory Services, Lindau,Switzerland*
6. *Bagnol,B. 2014. Conducting participatory monitoring and evaluation. Pages 81-85 in FAO, Decision tools for family poultry development. FAO Animal Production and Health Guidelines, No. 1 6.Rome, Italy:FAO.*

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9. *Boyle R & Le Maire D. (1999). Building effective evaluation capacity: lessons from practice. New Brunswick, NJ: TransactionPublishers.*
10. *Bradford, R.W., Duncan, P.J. &Tarcy, B. 1999. Simplified Strategic Planning: A No- nonsense Guide for Busy People Who Want Results Fast. New York: Chandler House.*
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12. *Chen H. 2012. Theory-driven evaluation: Conceptual framework, application and advancement. In: Strobl R., Lobermeier O., Heitmeyer W. (eds) Evaluation vonProgrammen und ProjektenfüreinedemokratischeKultur. Springer VS,Wiesbaden*
13. *Chen, H.T. 2011. Practical program evaluation: Theory-Driven Evaluation and the Integrated Evaluation Perspective. Thousand Oaks, CA: Sage.*
14. *Dale R. 2004. Evaluating Development Programmes and Projects, New Delhi, India: Sage Publications.*
15. *Duncan Haughey 2017. SWOT Analysis. https://www.projectsmart.co.uk/swot-analysis.php.*
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19. *Greene, J.C., Boyce,A., &Ahn, J. (2011). A values-engaged educative approach for evaluating education programs: A guidebook for practice. Champaign, IL: University of Illinoisat Urbana-Champaign.http://comm.eval.org/communities/community-home/librarydocuments/viewdocument?DocumentKey=f3c734c0-8166-4ba4-9808-a07e05294583*
20. *Greene J. 1988. Stakeholder participant and utilization in program evaluation.*
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22. *Karthikeyan, C., Vijayaraghavan, K. and Lavanya, P. 2007. Formative evaluation of Kisan Call Centres. Tamil Nadu. Indian Journal of Extension Education, 43(1 &2):20-25 (For LFAExample).*
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24. *Neuchatel Group. 2000. Guide for Monitoring, Evaluation and Joint Analyses of Pluralistic Extension Support. Lindau, Switzerland: NeuchâtelGroup.*

25. *www.g-fras.org/fileadmin/UserFiles/Documents/Frames-and-guidelines/M_E/ Guide-for-Monitoring-Evaluation-and-Joint-Analysis.pdf*
26. *Njuki J, Mapila M, Kaaria S and Magombo T. 2008. Using community indicators for evaluating research and development programmes: Experiences from Malawi. Development in Practice 18(4):633–642.*
27. *OECD. 1998. Review of the DAC Principles for Evaluation of Development Assistance.*
28. *Paris: DAC Working Party on Aid Evaluation. www.oecd.org/dataoecd/63/50/2065863.pdf (accessed 6 June 2011)*
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30. *Rosanne Lim .2012. Why You Should Do a SWOT Analysis for Project Management.*
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37. *http://www.meas-extension.org/meas-offers/training/evaluatingextensionprograms*
38. *Suvedi, M. and Kaplowitz, M.D. 2016. Process skills and competency tools – what every extension worker should know – Core Competency Handbook. Urbana, IL: USAID- MEAS.*
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40. *Venkateswarlu, K and Raman, K.V. 1993. Project Management Techniques for R&D in Agriculture. Sterling Publishers Pvt.Ltd., New Delhi.*
41. *Wholey JS, Harty HP and Newcomer KE. 1994. Handbook of practical program evaluation. San Francisco, USA: Jossey-BassPublisher*

WEBSITES

1. BETTER EVALUATION- www.betterevaluation.org

2.USAID-United States AgencyforInternationalDevelopment: Evaluation

3. https://www.usaid.gov/evaluationhttps://education.illinois.edu/faculty/jennifer-green

Ph.D. Programme

EXT-611POLICY ENGAGEMENT AND EXTENSION3(2+1)

Objectives

- To orient students on the importance of policies in shaping extension's performance
- To discuss ways of generating policy relevant evidence to influence policies
- To develop capacities to engage 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 this influence defining organisational roles and performance in extension organizations- Role of policies in upscaling 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); Policy advocacy 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 Societyvaried experiences: Understanding the environment and key actors 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

Unit1: Influencing Policy Change: -

Generating evidence: Role of policy research; analysing the usefulness and appropriateness of the evidence; Using evidence in policy advocacy; Understanding your audience: analysing 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 policy makers: 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.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Understanding Policy Why policies are important for extension?	1
2.	Role in providing structure, ensure funding and framework for providing functions-examples; Policy: definitions and types:	1
3.	Is policy a product or a process or both? Policies and institutions-How this influence defining organisational roles and performance in extension organizations-	2
4.	Role of policies in upscaling knowledge-Role of extension in influencing policies to enable innovation.	1
5.	Policy Advocacy and Tools Definition of advocacy, Approaches to policy advocacy-Advising, Media campaigning, Lobbying, Activism	2
6.	Information Education Communication (IEC) and Behavior Change Communication (BCC);	1
7.	Advocacy for Rural Advisory Services (RAS); Policy advocacy strategy	1
8.	Policy Analysis Explain the meaning and use of policy analysis in decision- making;	1
9.	Describe different types of policy analysis- empirical, evaluative or normative policy analysis, retrospective/ prospective policy analysis, predictive/prescriptive/descriptive policy analysis;	1
10.	How to do policy analysis? - understand the process of policy	2

	analysis, highlight the different methods and techniques used in policy analysis, doing ethical policy analysis;	
11.	Tools for policy impact- research tools, context assessment tools, communication tools, policy influence tools	1
12.	Policy Development Process Policy development process: Who drives policy change? National Governments, Donors, Civil Societyvaried experiences:	2
13.	Understanding the environment and key actors in policy space-problem identification-policy adoption, implementation and evaluation; stakeholder mapping, identifying opportunities and barriers, mobilising financial resources;	2
14.	Dealing with policy incoherence: identifying contradictions and challenges in policy implementation	1
15.	Influencing Policy Change Generating evidence: Role of policy research; analysing the usefulness and appropriateness of the evidence;	2
16.	Using evidence in policy advocacy; Understanding your audience: analysing channels of influence; creating alliances; identifying policy champions;	1
17.	Defining goals and objectives; Developing advocacy messages: Policy papers, Policy briefs, good practice notes etc.: good practices in influencing policies	2
18.	Organising policy dialogues: Policy engagement strategy-Engaging with policy makers: GO and NGO experiences;	1
19.	Policy working groups; advisory panels; use of committees: Use of media including ICTs and social media for influencing policies.	1
20.	Global Experience with Extension Policy Extension policy in different countries:	1
21.	Explicit extension policy Vs extension as part of Agriculture Policy, Challenges in policy implementation:	1
22.	lack of capacities, financial resources, ownership, lack of stakeholder consultations:	1
23.	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.	3
Total		**32**

Practical

1.Analysis of country/state level agricultural/extension policy to understand the policy intentions from strengthening EAS

2. Analysis of extension policy of other countries: policy intentions, processes adopted in development of the policy and mechanisms of policy implementation

3. 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

4. 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

5. Explore how different stakeholders influence policies (eg: policy advocacy of prominent NGOs, private sector and public sector) -What mechanisms and tools they use

6. 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.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Analysis of country/state level agricultural/extension policy to understand the policy intentions from strengthening EAS	2
2.	Analysis of extension policy of other countries: policy intentions, processes adopted in development of the policy and mechanisms of policy implementation	3
3.	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	3
4.	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	3
5.	Explore how different stakeholders influence policies (eg: policy advocacy of prominent NGOs, private sector and public sector) -What mechanisms and tools they use	2
6.	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.	3
Total		**16**

Suggested Readings

1. *AEPF. 2015. Report on the Policy Forum by Ghana Directorate of Agricultural Extension Services, Ministry of Food and Agriculture; Modernizing Extension and Advisory Services and AgriculturePolicySupportProject, Ghana.http://www.gras.org/en/knowledge/documents/category/18-policy.html?download=490:report-on-the-ghana-agricultural-extension-policy-forum-2015*
2. *Amosa, MDU. 2018. Policy Analysis and Engagement Toolkit.A guide for Pacific Non-governmentOrganizationsintheFisheriesSector. WWF.http://d2ouvy59p0dg6k.cloudfront.net/downloads/policy_analysis_toolkit_quality.pdf*
3. *Anonymous.NPolicyanalysis.http://www.egyankosh.ac.in/bitstream/123456789/25760/1/Unit-19.pdf*
4. *Anonymous.N.d.Policyanalysis.https://web.csulb.edu/~msaintg/ppa670/670steps.htm*
5. *Bardach E. A Practical Guide for Policy Analysis The Eightfold Path to More Effective Problem Solving Fourth Edition. Sage Publications. CQ Press.*
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7. *Cairney P. 2015.Chapter 2: Policymaking in the UK: What is Policy and How is it Made?.Policy and Policy making in the UK.https://paulcairney.files.wordpress.com/2013/08/chapter-2-20-8-13-cairney-policy-policymaking-uk.pdf*
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14. *FAO. 2013. FAO Policy on Gender Equality. Attaining Food Security Goals in Agriculture and Rural Development. Food and Agriculture Organization of the United Nations, Rome.http://www.fao.org/docrep/017/i3205e/i3205e.pdf*

15. *FAO. 2018. Policy Guidance Series. Strengthening Sector Policies for Better Food Security and Nutrition Results.Food and Agriculture Organization of the United Nations, Rome.http://www.fao.org/publications/policy-guidance-series/en/*
16. *GFRAS. 2018. RAS Policy Compendium. Global Forum for Rural Advisory Services, Switzerland.http://compendium.g-fras.org/*
17. *GoI. 2011.Report of the Working Group on Agricultural Extension for Agriculture and Allied Sectors for the Twelfth Five Year Plan (2012-17), Section V-Recommendations IV,73-74.*
18. *http://planningcommission.gov.in/aboutus/committee/wrkgrp12/agri/wg_agriextn.pdf*
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EXT-612METHODOLOGY FOR SOCIAL AND BEHAVIOURAL RESEARCH3(2+1)

Objectives

This course aims to equip the doctoral students to conduct outcome-oriented social and behavioural science research and to develop sound field focused extension strategies and models with adequate replicability, while advancing knowledge on processes governing success of those strategies. The focus of the course is on equipping 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

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– One-dimensionality 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, CriterionRelated 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 - In-depth 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, 42 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

Unit1: 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.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Measurement Properties of Research Instruments Measurement properties–Dimensionality,reliabilityandvalidity; Dimensionality– One-dimensionality and multidimensionality, Methods of assessing dimensionality, Formative and reflective constructs;	2
2.	Validity- Importance, Internal validity- face validity; content validity, Substantive Validity, Structural Validity; External validity - Convergent and Discriminant Validity, known-group validity, CriterionRelated Validity, Consequential Validity, nomological validity;	2
3.	Methods of assessing various forms of validities – Judges rating, Lawshe's Content Validity Ratio, Item-objective congruence index; latent variable method;	1
4.	Reliability-Internal consistency reliability-Split-Half, Cronbach alpha;TemporalStability reliability-test-retest method; Interrater Consistency and Consensus-inter rater reliability and interrater agreement; Alternative Forms or parallel form's reliability-Reliability of difference-Factors Affecting the Validity and Reliability of Test Scores; Generalizability Theory	2
5.	Threats to Data Quality Errors and biases; Errors – Meaning and sources; Types - Sampling error, non-sampling or measurement error and Processing error – Meaning, causes;	1
6.	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	1
7.	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;	2
8.	Scoring performance in scales and tests – meaning, types and methods; Scale development strategies – deductive and empirical;	1

9.	Stimulus-centred scales – method of equally appearing intervals, paired comparison, Person scaling – Q methodology; Subject-centre scales – The Likert scale and Semantic Differential	2
10.	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;	1
11.	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.	2
12.	Tests – meaning, types, importance; steps in conducting various tests – knowledge test	1
13.	Qualitative Research Methods Qualitative methods – Meaning; Types – Ethnography, Grounded theory, Phenomenology, Ecological psychology, Discourse Analysis;	1
14.	Observational research; Case study research – Sampling and sample size; Data collection methods - In-depth interviews, Focus groups, Direct observation, Record review; Content analysis; Unobtrusive Measures; Projective and semi-projective techniques;	2
15.	Selecting right qualitative method – Strengths and limitations of qualitative research; Analysis and interpretation of qualitative research data;	1
16.	Research synthesis – meaning, importance, methods; Systematic reviews and meta-analysis – meaning, steps, and applications; Policy research	1
17.	Emerging Approaches Mixed methods research – meaning, purpose, types and applications;	1
18.	Participatory research – Meaning, importance, types, methods and tools and applications; Action research – Meaning, importance, 42 Principles, Types, Steps in conducting action research, application in behavioural sciences.	2
19.	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	1
20.	Publishing Research Scholarly communication process; Research reports – Meaning, types, contents; Presentations – Meaning, types, principles of good presentation - Tell 'Em" and KISS 'Em" principles;	1
21.	Research publications – meaning, importance, types; Guidelines for preparing research papers - Peer review process,	1

	citation styles; Open access publishing; Publishing in social media. Software in academic writing	
22.	Ethics in Extension Research Ethics in conducting behavioural research; Human subject research – Meaning, history, and ethical guidelines;	1
23.	Ethical aspects of collecting and using Indigenous knowledge and farmers technologies; Ethical practices in publishing;	1
24.	Plagiarism-meaning,sources,Identifying and correcting plagiarism in a research paper using anti-plagiarism software	1
Total		**32**

Practical

1.Practice in developing research instruments Methods reliability of assessing measurement properties of research instruments dimensionality, and validity

2. Hands-on exercise in minimising errors and biases

3. Hands-on experience in constructing tests, scale and indexes

4. Practice in summated scale development using confirmatory factor analysis

5. Hands on experience in assessing measurement invariance

6. Practicing and collecting data using participatory tools and techniques, analyzing and interpreting qualitative data

7. Hands-on experience in writing systematic review using meta-analysis

8. Field practice in conducting action research

9. Practical experience in writing research paper

10. Hands on exercises using software for qualitative data analysis

11. Practice in detecting and correcting plagiarism using software.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Practice in developing research instruments Methods reliability of assessing measurement properties of research instruments dimensionality, and validity.	2
2	Hands-on exercise in minimising errors and biases. Hands-on experience in constructing tests, scale and indexes.	2
3	Practice in summated scale development using confirmatory factor analysis. Hands on experience in assessing measurement invariance.	2
4	Practicing and collecting data using participatory tools and techniques, analyzing and interpreting qualitative data.	2
5	Hands-on experience in writing systematic review using meta-analysis.	2
6	Field practice in conducting action research. Practical experience in writing research paper.	2
7	Hands on exercises using software for qualitative data analysis.	2

8	Practice in detecting and correcting plagiarism using software.	2
Total		**16**

Suggested Readings

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EXT-621TECHNOLOGY COMMERCIALISATION AND INCUBATION3(2+1)

Objectives

This course is aimed to develop a critical understanding among extension students about how the technology commercialization process is linked to IPR management and entrepreneurship development.

Theory

BLOCK 1: TECHNOLOGY COMMERCIALISATION AND THEMODERNCONTEXT

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 commercialization

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,InternationalUnionforProtectionofNewPlantVarieties(UPOV),andBIMSTEC.

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 bystakeholders.

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 commercializing farmers varieties and other biological resources; National Biodiversity Authority, Access to Genetic Resources and Sharing ofBenefits.

Unit 5: Protection, Management and commercialization of Grass root 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 andprocesses.

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

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 LevelCommittee.
(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 rootinnovations.

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 ratemethod.

Unit 3: Technology commercialization Strategies

Meaning- approaches for technology commercialization – 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 entrepreneurships – agripreneurs, startups, small businesses, Producer Organizations, Self Help Groups, Clusters and other forms ofentrepreneurship.

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 inIndia.

BLOCK 4: TECHNOLOGY INCUBATION

Unit 1: Basics of Technology Incubation

Meaning, functions and types; stakeholder-oriented incubation process – Livelihood incubation, villageincubators.

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 APPORACHES IN TECHNOLOGYCOMMERCIALISATIONAND INCUBATION

Unit 1: Technology Scouting

Technology Scouting and Innovations in technology incubation.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	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.	2
2.	Agricultural technology-meaning, types; technology generation system; technology life cycle.	1
3.	Technology transfer Vs Commercialisation; Technology commercialisation process-elements, models, systems and processes; Technology transfer model-research, disclosure, development and commercialisation.	1
4.	Introduction to IPR; Overview & Importance; Genesis; IPR in India and IPR abroad; Patents, copyrights, trademarks & trade secrets, geographical indication, industrial design;	1
5.	Emergence of IPR Regimes and Governance Frameworks - Trade-Related Aspects of Intellectual Property Rights (TRIPS), Convention on Biological Diversity (CBD), Cartagena Protocol,InternationalUnionforProtectionofNewPlantVarieties(UPOV),andBIMSTEC.	2
6.	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 bystakeholders.	1
7.	Mechanisms of IPR Management – Institutional arrangement, IP Management processes – invention disclosure; IP portfolio management; Infringement management.	1
8.	Introduction; National Biodiversity Act (2002); Protection of Plant Varieties and Farmers Rights Act (2001); Guidelines for	1

	registration and transfer of biological resources; Farmers rights;	
9.	Mechanisms of documenting/ collecting, protecting and commercializing farmers varieties and other biological resources; National Biodiversity Authority, Access to Genetic Resources and Sharing ofBenefits.	1
10.	Traditional and Indigenous Knowledge, Grassroot and Farmers Innovations – Meaning, forms and importance; Systems of documentation, registration, protection and commercialisation.	1
11.	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.	2
12.	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 andprocesses.	1
13.	The Global Concerns on Use of Genetically Modified Organisms in Food and Agriculture; The Cartagena Protocol on Bio-safety;	1
14.	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 LevelCommittee.	1
15.	(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	1
16.	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 rootinnovations.	1
17.	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 ratemethod.	2

18.	Meaning- approaches for technology commercialization – technology scaling up, technology licensing, handholding, agripreneur development, technology business incubation.	1
19.	Meaning, types and stages of technology, scaling up; mechanisms.	1
20.	Meaning and types - Procedures of licensing, preparing licensing documents; Management of technology licensing process.	1
21.	Meaning; types of technology takers; Technology Taking as a Strategy; Types of entrepreneurships – agripreneurs, startups, small businesses, Producer Organizations, Self Help Groups, Clusters and other forms ofentrepreneurship.	1
22.	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	1
23.	Innovation Mission and others; Entrepreneurship policy and schemes at different states of India; Organisations promoting entrepreneurship inIndia.	1
24.	Meaning, functions and types; stakeholder-oriented incubation process – Livelihood incubation, villageincubators.	1
25.	System of technology incubation- incubation process; its effectiveness; Managing profit oriented and non-profit incubators; Schemes for promoting incubators in India.	1
26.	Technology promotion – meaning, types, business meetings, scientist-industry/ entrepreneur meets, technology conclave, business plan competition, farmers' fairs, technology shows	1
27.	Business communication; Business Etiquette; business networking.	1
28.	Technology Scouting and Innovations in technology incubation.	1
Total		**32**

Practicals

1. Understanding the technology commercialization process – Visit to Technology commercialization Unit of ICAR Institute/ AgriculturalUniversity
2. Understanding the IPR protection practices – Visit to Patent Attorneyoffice
3. Hands-on experience in drafting IPR application – Patent/Copyright/Trademark
4. Understanding protection of biological resources including plant varieties – Visit to

PPVFRA Branch office/ ICAR Institute or Agricultural University involved in plant varietyprotection

5. Documenting Traditional and indigenous knowledge – Field experience in using various protocols of using traditional and indigenousknowledge
6. Protecting unique local goods through Geographical Indications – Hands on experiences in documenting and registering Geographicalindications
7. Technology assessment/ validation of traditional and indigenous knowledge – QuIK and othermethods
8. Hands on experience in technologyvaluation
9. Hands on experience in technology licensing process including draftingagreements
10. Understanding the Technology Business Incubation – Visit to Agri Business Incubator or Technology Businessincubator
11. Hands on experience in planning and organizing technology promotionevents
12. Hands on experience in various techniques in business communication and Business etiquette

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Understanding the technology commercialization process – Visit to Technology commercialization Unit of ICAR Institute/ Agricultural University	1
2.	Understanding the IPR protection practices – Visit to Patent Attorney office	1
3.	Hands-on experience in drafting IPR application – Patent/Copyright/ Trademar	1
4.	Understanding protection of biological resources including plant varieties – Visit to PPVFRA Branch office/ ICAR Institute or Agricultural University involved in plant variety protection	2
5.	Documenting Traditional and indigenous knowledge – Field experience in using various protocols of using traditional and indigenous knowledge	2
6.	Protecting unique local goods through Geographical Indications – Hands on experiences in documenting and registering Geographical indications	2
7.	Technology assessment/ validation of traditional and indigenous knowledge – QuIK and other methods	1
8.	Hands on experience in technology valuation	1
9.	Hands on experience in technology licensing process including drafting agreements	1
10.	Understanding the Technology Business Incubation – Visit to Agri Business Incubator or Technology Business incubator	2
11.	Hands on experience in planning and organizing technology promotion events	1
12.	Hands on experience in various techniques in business	1

	communication and Business etiquette	
Total		**16**

Suggested Readings

1. *Bandopadhyay, D. 2018.Securing Our Natural Wealth: A Policy Agenda for Sustainable Development in India and for Its Neighbouring Countries. Singapore; Springer.*
2. *Ghosh,S, and Joshi A. 2017.Handbook for Non-Profit Incubator Managers. New Delhi: Deutsche GesellschaftfürInternationale.*
3. *Gupta AK. 2016. Grassroots Innovation: Minds on the margin are not marginal minds. Gurgaon: Penguin Books.*
4. *ICAR.2018. ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization (Revised in 2018). Indian Council of Agricultural Research, NewDelhi*
5. *Pandey N and Dharni K. 2014.Intellectual Property Rights. Delhi. PHI Learning Pvt. Ltd.*
6. *Sharma G and Kumar H. 2018.Intellectual property rights and informal sector innovations: Exploring grassroots innovations in India. The Journal of World Intellectual Property. 1-17. DOI:https://doi.org/10.1111/jwip.12097.*
7. *Stevens AJ. 2016. Intellectual property valuation manual for academic institutions (Report No. CDIP/17/INF/4). Geneva: Committee on Development and Intellectual Property (CDIP).*
8. *WIPO and ITC. 2010. Exchanging Value – Negotiating Technology Licenses, A Training Manual. World Intellectual Property Organization (WIPO).*

EXT-622EDUCATIONAL TECHNOLOGY AND INSTRUCTIONAL DESIGN3(2+1)

Objectives

The aim is to develop knowledgeable, responsive and effective teachers committed to educating diverse group of learners in a dynamic extension landscape. This course will help the learners to appreciate the role of technology in learning and how it can be integrated into instructional design to create engaging learning experience in both classroom and online learning environment. The course also aims to prepare the students as competent professionals employable in the extension and RAS providers both as specialized researchers as well designers.

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 learningexperience

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 psychomotordomain

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 ine-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 RASecosystem.

Unit 2: Creating Instruction

Overview of planning, designing 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 learningenvironment.

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 teachingcompetencies.

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 instructionaldesign.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	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;	2
2.	What is the relevance of ET and ID relevant in extension and rural advisory services? Extensional professionals as instructional designers and architects of the learningexperience.	2
3.	What is learning? Critical overview of Behaviorism, Cognitivism, Constructivism and Complex learning theories; instructional designers and learning theories;	1
4.	Types of learning or learning domains- Bloom's taxonomy of the cognitive domain, Krathwohl and Bloom's affective domain and Simpson's psychomotordomain.	1
5.	What is the role of technology in education? Digital media, new tools and technology; Open and distance Learning (ODL);	1
6.	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;	2
7.	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;	2
8.	Augmented learning; Adaptive learning; meaning, features and	1

	good practices in using open-source Learning Management Systems (Moodle); Quality assurance and certification ine-learning.	
9.	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;	2
10.	ADDIE Model, Dick and Carey Model, SAM Model, Bloom's Taxonomy; integrating the theories of instruction into the practice of ID in extension and RASecosystem.	1
11.	Overview of planning, designing 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);	2
12.	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;	2
13.	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 learningenvironment.	2
14.	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;	2
15.	Methods of Delivery- classroom teaching, programmed instruction, synchronous and asynchronous modes of distance education; Changing role of a teacher in classroom and teachingcompetencies.	1
16.	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;	3
17.	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	2

	appraisal of teachers.	
18.	Alternatives to ADDIE model - Rapid prototyping and constructivist ID, reflections on instructional design as science and as an art;	1
19.	Relating ID models and process in extension learning environment; political economy of higher education in developed and developing countries;	1
20.	University assessment and rating methods, returns from agricultural higher education; research in education and instructionaldesign.	1
Total		**32**

Practical

1. 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 assessmentitems
2. 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/PGstudents
3. Assessing learning styles through Barsch and Kolbinventories
4. Development and testing of survey instruments for evaluating learning outcomes/ competencies of students
5. Development and testing of survey instruments for performance appraisal / competency assessment ofteachers.
6. 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 targetaudience
7. Designing and developing a theme-based knowledgeportal
8. ExercisesondesigninganonlinecourseusingopensourceLMSlikemoodleorEdX
9. Select and evaluate or design for social almedia
10. Preparea short research paper on recent theories and models of instructional design
11. 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
12. 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 variousfunctionalities
13. Field visit to a virtual learning / augmented learning lab, e-learning labs, distance learning centres,etc.
14. Hands-on practice with video-editing software, web conferencing and video conferencingsolutions

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	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 assessmentitems	2
2.	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/PGstudents	2
3.	Assessing learning styles through Barsch and Kolbinventories	1
4.	Development and testing of survey instruments for evaluating learning outcomes/ competencies of students	1
5.	Development and testing of survey instruments for performance appraisal / competency assessment ofteachers.	1
6.	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 targetaudience	1
7.	Designing and developing a theme-based knowledgeportal	1
8.	ExercisesondesigninganonlinecourseusingopensourceLMSlikemoodleorEdX	1
9.	Select and evaluate or design for social almedia	1
10.	Preparea short research paper on recent theories and models of instructional design	1
11.	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	1
12.	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 variousfunctionalities	1
13.	Field visit to a virtual learning / augmented learning lab, e-learning labs, distance learning centres,etc.	1
14.	Hands-on practice with video-editing software, web conferencing and video conferencingsolutions	1
Total		**16**

Suggested Readings

1. *Agarwal JC. 2007. Essentials of Educational Technology Innovations in Teaching – Learning. 2nd Ed. Vikas Publ. House.*
2. *Allen M. 2013. Leaving ADDIE for SAM: An Agile Model for Developing the Best Learning Experiences, https://www.alleninteractions.com/about*
3. *Anglin GJ (Ed.), 1995. Instructional technology: Past, present, and future. Englewood, CO: Libraries Unlimited.*

4. *Anonymous. 2000. Contents Pages of the Journal Educational Technology from January, 2OO0 to December, 2O15 Volume 40-Volume 55, http://publicationshare.com/pdfs/ET-Contents-Pages-2000-2015.PDF*
5. *Bandura A. 1977. Social learning theory. Englewood's Cliffs, NJ: Prentice-Hall*
6. *Bandura A. 2001. Social cognitive theory: An agentic perspective. Annual Review of Psychology, 52, 1–26*
7. *Britain S. 2004. A Review of Learning Design: Concept, Specifications and Tools. A report for the JISC E-learning Pedagogy Programme, May2004.*
8. *Brown AH and Timothy DG. 2016. The essentials of instructional design: connecting fundamental principles with process and practice, Third edition, Routledgehttps://ikhsanaira.files.wordpress.com/2016/05/the-essential-of-instructional-design.pdf*
9. *Challa J and Reddy NM. 2008. Education Technology for Agricultural Sciences, NAARM,Rajendra Nagar, Hyderabad, Telangana , India.*
10. *David HJ. 2003. Learning to Solve Problems: An Instructional Design Guide.*
11. *Duffy TM and Cunningham DJ. 1996. Constructivism: Implications for the design and delivery of instruction. In Jonassen D (Ed.), Handbook of Research for Educational Communications and Technology (pp. 170-198). New York: Simon & Schuster Macmillan Edward T. 2013. Power Point Is Evil. https://www.wired.com/2003/09/ppt2/*
12. *Ellen R. 2004. Instructional Design and Curriculum Development: Deconstructing the Difference, Educational Technology, Vol. 44, No. 2 (March-April 2004), pp. 3-12. https://www.jstor.org/stable/44428883*
13. *Gardner H. 2008. Multiple intelligences: New horizons in theory and practice. New York, NY: Basic Books.*
14. *Gayle VDS, Karen LR, Patrick RL. 2018. Web-Based Learning: Design, Implementation and Evaluation, 2nd Edition Hsu YC, Hung JL, and Ching YH. 2013. Trends of educational technology research: More than a decade of international research in six SSCI-indexed refereed journals. Educational Technology Research and Development, 61(4), 685-705. https://www.academia.edu/1141731/Aesthetic_principles_for_instructional_design?auto=download*
15. *James ML. 2006. Small Teaching: Everyday Lessons from the Science of Learning*
16. *Kolb D. 2014. Experiential learning: Experience as the source of learning and development (2nd ed.). Upper Saddle River, NJ: PrenticeHall*
17. *Koper R. 2006.Current Research in Learning Design, Educational Technology & Society, 9 (1),13–22.*
18. *Kozma RB. 1994. Will media influence learning? Reframing the debate. Educational Technology Research & Development, 42(2), 7-19.*
19. *Merrill MD, Drake L, Lacy M J and Pratt J. 1996. Reclaiming instructional design (PDF). Educational Technology. 36 (5): 5–7. Archived (PDF) from the original on 2012-04-26.*

20. *Parrish PE. 2007. Aesthetic principles for instructional design, Education Technology Research and Development, DOI 10.1007/s11423-007-9060-7*
21. *Parrish PE. 2005. Embracing the aesthetics of instructional design. Educational Technology, 45(2), 16–25.*
22. *Reiser RA, Mackal M, and Sachs SG . 2005. Textbooks used in graduate programs in instructional design and technology: Changes over the past twelve years. Educational Technology, 45(5), 53 -61.*
23. *Reiser RA. 2001.A History of Instructional Design and Technology: Part I: A History of Instructional Media. Educational Technology Research and Development, 49 (1), 53-64.*
24. *Reiser RA. 2001. A History of Instructional Design and Technology: Part II: A History ofInstructionalDesign.EducationalTechnologyResearchandDevelopment,49(2),57-67.*
25. *Spector JM, Merrill MD, Elen J and Bishop MJ. (Eds.), 2014.Handbook of research on educational communications and technology (4th ed.). New York: Springer.*
26. *Spector JM. 2015. Foundations of educational technology: Integrative approaches and interdisciplinary perspectives. Routledge.*
27. *Spiro R. 2018. Cognitive Flexibility Theory & the Post-Gutenberg Mind: Rand Spiro's Home Page,*
28. *https://postgutenberg.typepad.com/newgutenbergrevolution/?utm_campaign=elearningindustry.com&utm_source=%2Fcognitive-flexibility-theory&utm_medium=link*
29. *Tennyson R, Dijkstra S, Schott F and Norbert S. 1997.Instructional Design: International Perspectives. Theory, Research, And Models.Vol. 1. Mahwah, NJ: Lawrence Erlbaum Associates, Inc. p. 42. ISBN 0805814000.*
30. *The Encyclopedia of Educational Technology. What is Educational Technology? http://www.etc.edu.cn/eet/eet/articles/edtech/index.htm*
31. *Wlodkowski, Raymond J. 2008. Enhancing adult motivation to learn : a comprehensive guide for teaching all adults, 3rd ed., The Jossey-Bass higher and adult education series, http://ekladata.com/iJLoOLufKEurVuG5mA2Ke1rJ5dQ/-Raymond_J._Wlodkowski-*
32. *_Enhancing_adult_motivation-Bokos-Z1-.pdf*

*WEBSITES**Learning Industry-https://elearningindustry.com/***

1. *Instructional Design Central- https://www.instructionaldesigncentral.com/*
2. *Instructional Design- http://www.instructionaldesign.org/theories/*
3. *International Society for Educational Technology-https://www.isfet.org/courses/*
4. *EducationalTechnology-https://educationaltechnology.net/*
5. *AESA-Agricultural Extension in South Asia http://www.aesanetwork.org/*
6. *GFRAS-Global Forum for Rural Advisory Services http://www.g-fras.org/en/*

AGRONOMY

Semester-Wise Distribution of Courses

S. No.	Course No.	Title	Credit Hrs.
M.Sc.(Ag.)Semester-I			
1.	**AGRON-511**	**PRINCIPLES AND PRACTICES OF WATER MANAGEMENT**	**3(2+1)**
2.	**AGRON-512**	**PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT**	**3(2+1)**
3.	**AGRON-513**	**PRINCIPLES AND PRACTICES OF ORGANIC FARMING**	**2(1+1)**
Minor Courses			
4.	**SOIL-513**	**ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS**	**2(0+2)**
Supporting Courses			
5.	**STAT-511**	**STATISTICAL METHODS FOR APPLIED SCIENCES**	**3(2+1)**
Common Courses			
6.	**PGS-511**	**LIBRARY AND INFORMATION SERVICES**	**1(0+1)**
Total			**14**
Semester-II			
1.	**AGRON-521**	**MODERN CONCEPTS IN CROP PRODUCTION**	**3(3+0)**
2.	**AGRON-522**	**PRINCIPLES AND PRACTICES OF WEED MANAGEMENT**	**3(2+1)**
3.	**AGRON-523**	**DRYLAND FARMING AND WATERSHED MANAGEMENT**	**3(2+1)**
Minor Courses			
4.	**PPHYS-521**	**PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES**	**3(2+1)**
Supporting Courses			
5.	**STAT-521**	**EXPERIMENTAL DESIGNS**	**3(2+1)**
Total			**15**
Semester-III			

1.	**AGRON -531**	**AGRONOMY OF MAJOR CEREALS AND PULSES**	**3(2+1)**
Minor Courses			
2.	**SOIL-512**	**SOIL MINERALOGY,GENESIS AND CLASSIFICATION**	**3(2+1)**
Common Courses			
3.	**PGS -531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4.	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5.	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6.	**PGS-534**	**AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
	AGRON -543	**RESEARCH**	**30**
Semester-IV			
1.	**AGRON -541**	**MASTER'S SEMINAR**	**1(0+1)**
2.	**AGRON -542**	**COMPREHENSIVE**	**NC**
3.	**AGRON -543**	**RESEARCH**	**30**
Non Core Courses			
1.	**AGRON - 505**	**CONSERVATION AGRICULTURE**	**2(1+1)**
2.	**AGRON - 507**	**AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS**	**3(2+1)**
3.	**AGRON - 508**	**AGRONOMY OF MEDICINAL, AROMATIC AND UNDERUTILIZED CROPS**	**3(2+1)**
4.	**AGRON - 506**	**CROPPING SYSTEM AND SUSTAINABLE AGRICULTURE**	**2(2+0)**
5.	**AGRON - 509**	**AGRONOMY OF FODDER AND FORAGE CROPS**	**3(2+1)**
6.	**AGRON- 510**	**AGROSTOLOGY AND AGRO FORESTRY**	**3(2+1)**

Ph.DSemester-I			
1.	**AGRON - 611**	**CURRENT TRENDS IN AGRONOMY**	**3(3+0)**
2.	**AGRON- 612**	**RECENT TRENDS IN CROP GROWTH AND PRODUCTIVITY**	**3(2+1)**
Minor Courses			
3.	**SOIL-511/512**	**SOIL CHEMISTRY/ SOIL MINERALOGY,GENESIS AND**	**3(2+1)**

		CLASSIFICATION	
Supporting courses			
4.	**PPHYS-513**	**PHYSIOLOGY OF FIELD CROPS**	**2(2+0)**
Total			**11**
SEMESTER-II			
1.	**AGRON- 621**	**RESEARCH AND PUBLICATION ETHICS**	**2(2+0)**
2.	**AGRON -622**	**RECENT TRENDS IN WEED MANAGEMENT**	**2(2+0)**
3.	**AGRON- 623**	**IRRIGATION MANAGEMENT**	**2(2+0)**
Minor Courses			
4.	**PPHYS-523/PPHYS-522**	**SEED PHYSIOLOGY/PLANT DEVELOPMENTAL BIOLOGY: PHYSIOLOGICAL AND MOLECULAR BASIS**	**3(2+1)**
Supporting courses			
5.	**SOIL-522/SOIL-521**	**SOIL BIOLOGY AND BIOCHEMISTRY/SOIL FERTILITY AND FERTILIZER USE**	**3(2+1)**
Total			**12**
Semester – III and onward			
1.	**AGRON-641**	**DOCTORAL SEMINAR-I**	**1(0+1)**
2.	**AGRON-642**	**DOCTORAL SEMINAR-II**	**1(0+1)**
3.	**AGRON-643**	**COMPREHENSIVE**	**NC**
4.	**AGRON-644**	**RESEARCH**	**75**
Non Core Courses			
1.	**AGRON -605**	**INTEGRATED FARMING SYSTEMS FOR SUSTAINABLE AGRICULTURE**	**2+0**
2.	**AGRON- 606**	**SOIL CONSERVATION AND WATERSHED MANAGEMENT**	**2+1**
3.	**AGRON-607**	**STRESS CROP PRODUCTION**	**2+1**

* core course

Non core courses adopted and approved in BoS,out of which one or more courses may be opted in future as and when need arises in future

M.Sc.Programme

AGRON 511 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT 3(2+1)

Theory

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and Rajasthan, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-waterplant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

Unit IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII

Hydroponics,

Unit IX

Water management of crops under climate change scenario.

Lecture Schedule- Theory

S. No.	Topics	No. of Lectures
1.	Water, its properties and role in plants	1
2.	Irrigation: Definition and objectives, water resources and irrigation development in India and Rajasthan	1
3.	Major irrigation projects, extent of area and crops irrigated in India and in Rajasthan.	2
4.	Field water cycle, water movement in soil and plants	1
5.	Transpiration; types and approaches to reduce transpiration, Soil-water-plant relationships; water absorption by plants;	2

6.	Plant response to water stress, crop plant adaptation to moisture stress condition.	2
7.	Water availability and its relationship with nutrient availability and loses.	1
8.	Soil, plant and meteorological factors determining water needs of crops	1
9.	Scheduling, depth and methods of irrigation;	1
10.	Micro irrigation systems; deficit irrigation; fertigation;	1
11.	Management of water in controlled environments and polyhouses, Irrigation efficiency, water use efficiency and factor affecting it	2
12.	Water management of crops and cropping systems,	2
13.	Crop water requirement- estimation of ET and effective rainfall	1
14.	Water management of the major crops and cropping systems. Automated irrigation system.	2
15.	Excess of soil water and plant growth;	1
16.	Drainage requirement of crops and methods of field drainage, their layout and spacing;	2
17.	Rain water management and its utilization for crop production	1
18.	Quality of irrigation water and management of saline water for irrigation,	1
19.	Water management in problematic soils	1
20.	Soil moisture conservation – concepts and techniques	1
21.	Water harvesting, rain water management and its utilization for crop production.	2
22.	Hydroponics – an introduction, its components and types	1
23.	Water management of crops under climate change scenario	2
Total		**32**

Practical

1. Determination of Field capacity by field method
2. Determination of Permanent Wilting Point by sunflower pot culture technique
3. Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
4. Determination of Hygroscopic Coefficient
5. Determination of maximum water holding capacity of soil
6. Measurement of matric potential using gauge and mercury type tensiometer
7. Determination of soil-moisture characteristics curves
8. Determination of saturated hydraulic conductivity by constant and falling head method
9. Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
10. Measurement of soil water diffusivity
11. Estimation of unsaturated hydraulic conductivity

12. Estimation of upward flux of water using tensiometer and from depth ground water table
13. Determination of irrigation requirement of crops (calculations)
14. Determination of effective rainfall (calculations)
15. Determination of ET of crops by soil moisture depletion method
16. Determination of water requirements of crops
17. Measurement of irrigation water by volume and velocity-area method
18. Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
19. Determination of infiltration rate by double ring infiltrometer

Lecture Schedule- Practical

S.No.	Topics	No. of Lectures
1.	Determination of FC and PWP	1
2.	Determination of Hygroscopic Coefficient	1
3.	Determination of maximum water holding capacity of soil	1
4.	Measurement of matric potential using gauge and mercury type tensiometer	1
5.	Determination of soil-moisture characteristics curves	1
6.	Determination of hydraulic conductivity in saturated soil by different methods	1
7.	Estimation of unsaturated hydraulic conductivity	1
8.	Measurement of soil water diffusivity	1
9.	Estimation of upward flux of water using tensiometer and from depth ground water table	1
10.	Determination of irrigation requirement of crops (calculations)	1
11.	Determination of effective rainfall (calculations)	1
12.	Determination of ET of crops by soil moisture depletion method	1
13.	Determination of water requirements of crops	1
14.	Measurement of irrigation water by volume and velocity-area method	1
15.	Measurement of irrigation water by measuring devices and calculation of irrigation efficiency	1
16.	Determination of infiltration rate	1
Total		**16**

Suggested Readings

1. *Majumdar DK. 2014. Irrigation Water Management: Principles and Practice. PHL Learning private publishers*
2. *Mukund Joshi. 2013. A Text Book of Irrigation and Water Management Hardcover, Kalyani publishers*
3. *Lenka D. 1999. Irrigation and Drainage. Kalyani.*

4. *Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.*
5. *Paliwal KV. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi.*
6. *Panda SC. 2003. Principles and Practices of Water Management. Agrobios.*
7. *Prihar SS and Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.*
8. *Reddy SR. 2000. Principles of Crop Production. Kalyani.*
9. *Singh Pratap and Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.*

AGRON 512 PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT 3(2+1)

Theory

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermicompost and residue wastes in crops.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Soil fertility and productivity concept, differences and factors affecting	1
2.	Features of a good soil management	2
3.	Problems of supply and factors affecting availability of nutrients	2
4.	Relation between nutrient supply and crop growth	1
5.	Organic farming - basic concepts and definitions	2
6.	Criteria of essentiality of nutrients, essential plant nutrients –	3

	their functions, nutrient deficiency symptoms	
7.	Transformation and dynamics of major plant nutrients	2
8.	Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses	3
9.	Recycling of organic wastes and residue management	1
10.	Soil less cultivation	1
11.	Commercial fertilizers; composition, relative fertilizer value and cost, fertilizer mixtures and grades	3
12.	Crop response to different nutrients	2
13.	Residual effects and fertilizer use efficiency; agronomic, chemical and physiologicalmethods	2
14.	Methods of increasing fertilizer use efficiency	1
15.	Nutrient interactions	1
16.	Time and methods of manures and fertilizers application	1
17.	Foliar application and its concept	1
18.	Relative performance of organic and inorganic nutrients and economics of fertilizer use	1
19.	Integrated nutrient management	1
20.	Residue wastes in crops	1
Total		**32**

Practical

1. Determination of soil pH and soil EC
2. Determination of soil organic C
3. Determination of available N, P, K and S of soil
4. Determination of total N, P, K and S of soil
5. Determination of total N, P, K, S in plant
6. Computation of optimum and economic yield

Lecture Schedule – Practical

S. No.	Topics	No. of Lectures
1.	Determination of soil pH and soil EC	2
2.	Determination of soil organic C	2
3.	Determination of available N, P, K and S of soil	4
4.	Determination of total N, P, K and S of soil	2
5.	Determination of total N, P, K, S in plant	4
6.	Computation of optimum and economic yield	2
Total		**16**

Suggested Readings

1. *Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.*
2. *Fageria NK, Baligar VC and Jones CA. 1991. Growth and Mineral Nutrition of Field Crops. Marcel Dekker.*
3. *Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.*
4. *Prasad R and Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.*
5. *Yawalkar KS, Agrawal JP and Bokde S. 2000. Manures and Fertilizers. Agri-Horti Publ.*

AGRON 513 PRINCIPLES AND PRACTICES OF ORGANIC FARMING 2(1+1)

Theory

Unit I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organics and farming standards; organic farming and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

Unit II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, bio-fertilizers and biogas technology.

Unit III

Farming systems, selection of crops andcrop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

Unit IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides.

Unit V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Organic farming - concept and definition, its relevance to India and global agriculture and future prospects	1
2.	Principles of organic agriculture, organics and farming standards	1
3.	Organic farming and sustainable agriculture	1

4.	Selection and conversion of land, soil and water management - land use,conservation tillage,shelter zones, hedges, pasture management, agro-forestry	2
5.	Organic farming and water use efficiency	1
6.	Soil fertility, nutrient recycling, organic residues, organic manures, composting, green manures, soil biota and decomposition of organic residues,	1
7.	Earthworms and vermicompost	1
8.	Bio-fertilizers and biogas technology	1
9.	Farming systems, selection of crops andcrop rotations,	1
10.	Multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity	1
11.	Weed management,diseases and insect pest management	1
12.	Biological agents, pheromones and bio-pesticides	1
13.	Socio-economic impacts, marketing and export potentialof organic farming	1
14.	Inspection, certification, labeling and accreditation procedures	1
15.	Organic farming and national economy	1
Total		**16**

Practical

1. Method of making compost by aerobic method
2. Method of making compost by anaerobic method
3. Method of making vermicompost
4. Identification and nursery raising of important agro-forestry tress and tress for shelter belts
5. Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium cultures, use of Azotobacter, Azospirillum, and PSB cultures in field • Visit to a biogas plant
6. Visit to an organic farm
7. Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Method of making compost by aerobic method	2
2.	Method of making compost by anaerobic method	2
3.	Method of making vermicompost	2
4.	Identification and nursery raising of important agro-forestry tress and tress for shelter belts	2
5.	Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium cultures, use of Azotobacter, Azospirillum, and PSB cultures in field	2

6.	Visit to a biogas plant	1
7.	Visit to an organic farm	2
8.	Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms	3
Total		**16**

Suggested Readings

1. *Ananthakrishnan TN. (Ed.). 1992. Emerging Trends in Biological Control of Phytophagous Insects. Oxford & IBH.*
2. *Gaur AC. 1982. A Manual of Rural Composting, FAO/UNDP Regional Project Document, FAO.*
3. *Joshi M. 2016. New Vistas of Organic Farming. Scientific Publishers*
4. *Lampin N. 1990. Organic Farming. Press Books, lpswitch, UK.*
5. *Palaniappan SP and Anandurai K. 1999. Organic Farming – Theory and Practice. Scientific Publ.*
6. *Rao BV Venkata. 1995. Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective: Publ.3, ParisaraprajnaParishtana, Bangalore.*
7. *Reddy MV. (Ed.). 1995. Soil Organisms and Litter Decomposition in the Tropics. Oxford & IBH.*
8. *Sharma A. 2002. Hand Book of Organic Farming. Agrobios.*
9. *Singh SP. (Ed.). 1994. Technology for Production of Natural Enemies. PDBC, Bangalore.*
10. *Subba Rao NS. 2002. Soil Microbiology. Oxford & IBH.*
11. *Trivedi RN. 1993. A Text Book of Environmental Sciences, Anmol Publ.*
12. *Veeresh GK, Shivashankar K and Suiglachar MA. 1997. Organic Farming and Sustainable Agriculture. Association for Promotion of Organic Farming, Bangalore.*
13. *WHO. 1990. Public Health Impact of Pesticides Used in Agriculture. WHO.*
14. *Woolmer PL and Swift MJ. 1994. The Biological Management of Tropical Soil Fertility. TSBF & Wiley.*

AGRON 521 MODERN CONCEPTS IN CROP PRODUCTION 3(3+0)

Unit I

Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

Unit IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

Unit V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Crop growth analysis in relation to environment: LAI, CGR, RGR, NAR, LAD	2
2.	Geo-ecological and agroclimatic zones of India and Rajasthan	2
3.	Quantitative agro-biological principles and inverse yield nitrogen law	2
4.	Mitscherlich yield equation, its interpretation and applicability	2
5.	Baule unit	2
6.	Effect of lodging in cereals	1
7.	Physiology of grain yield in cereals	2
8.	Optimization of plant population and planting geometry in relation to different resources	2
9.	Concept of ideal plant type and crop modeling for desired crop yield, characteristics of an ideotype plant for dryland agriculture	3
10.	Scientific principles of crop production	2
11.	Crop response production functions	2
12.	Concept of soil plant relations	2
13.	Abiotic and biotic stresses; yield and environmental stress, seed priming,use of growth hormones and regulators for better adaptation in stressed condition	3
14.	Integrated farming systems	2
15.	Organic farming – definition, differences between conventional and organic farming and principles and components of organic farming	2
16.	Resource conservation technology including modern concept	2

	of tillage - zero tillage, minimum tillage, furrow irrigated raised bed system, conservation tillage -its advantages, disadvantages andtypes	
17.	Dry farming	1
18.	Determining the nutrient needs for yield potentiality of crop plants	2
19.	Concept of balance nutrition and integrated nutrient management	1
20.	Precision agriculture-definition, basic concept, scope and approach	2
21.	Modern crop production concepts	2
22.	Soil less cultivation	1
23.	Aeroponic, Hydroponic, Robotic and terrace farming	3
24.	Use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture	3
Total		**48**

Suggested Readings

1. *Balasubramaniyan P and Palaniappan SP. 2001. Principles and Practices of Agronomy.Agrobios.*
2. *Fageria NK. 1992. Maximizing Crop Yields. Marcel Dekker.*
3. *Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. Soil Fertility and Fertilizers. 7thEd. Prentice Hall.*
4. *Paroda R.S. 2003. Sustaining our Food Security. Konark Publ.*
5. *Reddy SR. 2000. Principles of Crop Production. Kalyani Publ.*
6. *Sankaran S and Mudaliar TVS. 1997. Principles of Agronomy. The Bangalore Printing & Publ.*
7. *Singh SS. 2006. Principles and Practices of Agronomy. Kalyani.*
8. *Alvin PT and kozlowski TT (ed.). 1976. Ecophysiology of Tropical Crops. Academia Pul., New York.*
9. *Gardner PP, Pearce GR and Mitchell RL. 1985. Physiology of Crop Plants. Scientific Pub. Jodhpur.*
10. *Lal R. 1989. Conservation tillage for sustainable agriculture: Tropics versus Temperate Environments. Advances in Agronomy 42: 85-197.*

Wilsie CP. 1961. Crop Adaptation and Distribution. Euresia Pub., New Delhi.

AGRON 522 PRINCIPLES AND PRACTICES OF WEED 3(2+1)

MANAGEMENT

Theory

Unit I

Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and classification management; weed indices, weed shift in different eco-systems

Unit II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allelochemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combination and rotation.

Unit IV

Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit V

Integrated weed management; recent development in weed management- robotics, use of drones and aeroplanes, organic etc., cost: benefit analysis of weed management.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Weed biology, ecology and classification, crop-weed competition including allelopathy	2
2.	Principles and methods of weed control and classification management	2
3.	Weed indices, weed shift in different eco-systems	1
4.	Herbicides- introduction and history of their development	1
5.	Classification based on chemical, physiological application and selectivity	1
6.	Properties, mode and mechanism of action of herbicides	2
7.	Herbicide structure - activity relationship	2
8.	Factors affecting the efficiency of herbicides	1
9.	Herbicide formulations, herbicide mixtures, adjuvants and safeners, sequential application of herbicides, rotation	2
10.	Weed control through use of nano-herbicides and bio-	1

	herbicides, myco-herbicides, bio-agents and allelochemicals	
11.	Movement of herbicides in soil and plant	2
12.	Degradation of herbicides in soil and plants	1
13.	Herbicide resistance, residue, persistence and management	1
14.	Development of herbicide resistance in weeds and crops and their management	1
15.	Herbicide combination and rotation	1
16.	Weed management in major crops and cropping systems a) Grain crops b) Oilseeds and pulses c) Sugar and fibre crops d) Tuber and forage crops e) Weed control under intercropping system, drylands and non-cropped area	4
17.	Noxious, alien, invasive and parasitic weeds and their management	2
18.	Weed shifts in cropping systems	1
19.	Aquatic and perennial weeds and their control	1
20.	Integrated weed management	1
21.	Recent development in weed management- robotics, use of drones and aeroplanes, organic etc.	1
22.	Cost: benefit analysis of weed management	1
Total		**32**

Practical

1. Identification of important weeds of different crops, Preparation of a weedherbarium, Weed survey in crops and cropping systems, Crop-weed competition studies, Weed indices calculation and interpretation with data, Preparation of spray solutions of herbicides for high and low-volume sprayers, Use of various types of spray pumps and nozzles and calculation of swath width, Economics of weed control, Herbicide resistance analysis in plant and soil,
2. Bioassay of herbicide resistance residues,
3. Calculation of herbicidal herbicide requirement

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Identification of important Kharif and Rabi weeds	1
2.	Identification of perennial weeds of crop fields, road sides, wastelands and irrigation channels	1
3.	Preparation of a weed herbarium	1
4.	Weed survey in crops and cropping systems	1
5.	Crop-weed competition studies	1

6.	Weed indices calculation and interpretation with data	1
7.	Familiarization with trade names, common names, uses, cost and sources of availability of herbicides	1
8.	Preparation of spray solutions of herbicides for high and low-volume sprayers	1
9.	Use of various types of spray pumps and nozzles and calculation of swath width	1
10.	Economics of weed control	1
11.	Herbicide resistance analysis in plant and soil	2
12.	Bioassay of herbicide resistance residues	2
13.	Calculation of herbicidal requirement	2
Total		**16**

Suggested Readings

1. *Boger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.*
2. *Chauhan B and Mahajan G. 2014. Recent Advances in Weed Management. Springer.*
3. *Das TK. 2008. Weed Science: Basics and Applications, Jain Brothers (New Delhi).*
4. *Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.*
5. *Gupta OP. 2007. Weed Management: Principles and Practices, 2nd Ed.*
6. *Jugulan, Mithila (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press • Monaco TJ, Weller SC and Ashton FM. 2014. Weed Science Principles and Practices, Wiley*
7. *Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.*
8. *Walia US. 2006. Weed Management, Kalyani.*
9. *Zimdahl RL. (ed). 2018. Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub.*

AGRON 523 DRYLAND FARMING AND WATERSHED MANAGEMENT 3(2+1)

Theory

Unit I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

Unit II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought,

characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

Unit III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

Unit IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

Unit V

Concept of watershed resource management, problems, approach and components.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Dryland farming- definition and concept	1
2.	Characteristics of dry land farming, dry land versus rainfed farming	2
3.	Significance and dimensions of dry land farming in Indian agriculture	2
4.	Soil and climatic parameters with special emphasis on rainfall characteristics	2
5.	Constraints limiting crop production in dry land areas	2
6.	Drought – definition and types of drought	1
7.	Characterization of environment for water availability	1
8.	Crop planning for erratic and aberrant weather conditions	1
9.	Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies	2
10.	Preparation of appropriate crop plans for dry land areas	2
11.	Mid season contingent plan for aberrant weather conditions	2
12.	Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage	2
13.	Concept of conservation tillage	1
14.	Tillage in relation to weed control and moisture conservation	1
15.	Techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics)	2
16.	Antitranspirants- their types, mechanism and role in dry farming	2
17.	Soil and crop management techniques, seeding and efficient fertilizer use	2
18.	Concept of watershed resource management, problems, approach and components	3
19.	Water harvesting –concepts, techniques and practices	1

Total	32

Practical

1. Method of Seed Priming
2. Determination of moisture content of germination of important dryland crops
3. Determination of Relative Water Content and Saturation Deficit of Leaf
4. Moisture stress effects and recovery behaviour of important crops
5. Estimation of Potential ET by Thornthwaite method
6. Estimation of Reference ET ny Penman Monteith Method
7. Classification of climate by Thornthwaite method (based on moisture index,humidity index and aridity index)
8. Classification of climate by Koppen Method
9. Estimation of water balance by Thornthwaite method
10. Estimation of water balance by FAO method
11. Assessment of drought
12. Estimation of length of growing period
13. Estimation of probability of rain and crop planning for different drought condition
14. Spray of anti-transpirants and their effect on crops
15. Water use efficiency
16. Visit to dryland research stations and watershed projects

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Method of Seed Priming	1
2.	Determination of moisture content of germination of important dryland crops	1
3.	Determination of Relative Water Content and Saturation Deficit of Leaf	1
4.	Moisture stress effects and recovery behaviour of important crops	1
5.	Estimation of Potential ET by Thornthwaite method	1
6.	Estimation of Reference ET by Penman Monteith Method	1
7.	Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)	1
8.	Classification of climate by Koppen Method	1
9.	Estimation of water balance by Thornthwaite method	1
10.	Estimation of water balance by FAO method	1
11.	Assessment of drought	1
12.	Estimation of length of growing period	1
13.	Estimation of probability of rain and crop planning for different drought condition	1
14.	Spray of anti-transpirants and their effect on crops	1

15.	Water use efficiency	1
16.	Visit to dryland research stations and watershed projects	1
Total		**16**

Suggested Readings

1. *Reddy TY. 2018. Dryland Agriculture Principles and Practices, Kalyani publishers*
2. *Das NR. 2007. Tillage and Crop Production. Scientific Publ.*
3. *Dhopte AM. 2002. Agrotechnology for Dryland Farming. Scientific Publ.*
4. *Dhruv Narayan VV. 2002. Soil and Water Conservation Research in India. ICAR.*
5. *Gupta US. (Ed.). 1995. Production and Improvements of Crops forDrylands. Oxford & IBH.*
6. *Katyal JC and Farrington J. 1995. Research for Rainfed Farming. CRIDA.*
7. *Rao SC and Ryan J. 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publ.*
8. *Singh P and Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ. Company.*
9. *Singh RP. 1988. Improved Agronomic Practices for Dryland Crops. CRIDA.*
10. *Singh RP. 2005. Sustainable Development of Dryland Agriculture in India. Scientific Publ.*
11. *Singh SD. 1998. Arid Land Irrigation and Ecological Management. Scientific Publ.*
12. *Venkateshwarlu J. 2004. Rainfed Agriculture in India. Research and Development Scenario. ICAR.*

AGRON 531 AGRONOMY OF MAJOR CEREALS AND PULSES 3(2+1)

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of:

Unit I: Rabi cereals.

Unit II: Kharif cereals.

Unit III: Rabi pulses.

Unit IV: Kharif pulses.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	**Rice** Origin and history, importance, production, distribution, adaptability and classification, cropping systems Climate, soil and cultural requirements and improved varieties Nutrient, water and weed management Crop protection, handling and processing of produce, quality components and industrial uses of main and by products	4
2.	**Maize**	4

	Origin and history, importance, production, distribution and classification Climate, soil and cultural requirements and improved varieties Nutrient, water, weed management and quality components Crop protection, handling and processing of produce, prospects of rabi maize cultivation in India	
3.	**Sorghum :** Origin and history, importance, production and distribution Climate, improved varieties, soil and cultural requirements Nutrient, water and weed management Crop protection, handling and processing of produce and quality components	4
4.	**Pearl millet :** Origin and history, importance, production, distribution and cropping systems Climate, improved varieties, soil and cultural requirements for maximization of production Nutrient, weed and water management Plant protection, quality components and industrial uses of the main and by products.	3
5.	**Wheat** Origin and history, importance, production, distribution, adaptability and classification Cropping systems, adaptability, climate and improved varieties, soil and cultural requirements Nutrient, water and weed management in relation to latest research Crop protection, handling and processing of produce	4
6.	**Barley** Origin and history, importance, production, distribution, classification Climate, improved varieties, soil and cultural requirements Nutrient, water and weed management Crop protection, handling and processing of produce, quality components and industrial uses of the main and by products.	3
7.	Acquaintance about important minor millets	2
8.	**Pigeon pea :** Origin and history, importance, protection and distribution, classification, morphology and phenology, cropping systems Adaptability, climate, soil and improved varieties Nutrient, water and weed management, crop protection, handling and processing of produce.	3
9.	**Chickpea** :	3

	Origin and history, importance, production and distribution, classification, morphology and phenology, cropping systems, adaptability, Climate, soil and cultural requirement for maximization of production and improved varieties Nutrient, water and weed management, crop protection, handling and processing of produce	
10.	Package of practices of common pulses; greengram, blackgram, cowpea, mothbean, lentil	2
Total		**32**

Practical

1. Phenological studies at different growth stages of crop
2. Estimation of crop yield on the basis of yield attributes
3. Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
4. Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW, etc)
5. Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)
6. Estimation of protein content in pulses
7. Planning and layout of field experiments
8. Judging of physiological maturity in different crops
9. Intercultural operations in different crops
10. Determination of cost of cultivation of different crops
11. Working out harvest index of various crops
12. Study of seed production techniques in selected crops
13. Visit of field experiments on cultural, fertilizer, weed control and water management aspects
14. Visit to nearby villages for identification of constraints in crop production

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Phenological studies at different growth stages of crop	1
2.	Estimation of crop yield on the basis of yield attributes	1
3.	Formulation of cropping schemes for various farm sizes and calculation of croppingand rotational intensities	1
4.	Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLWetc.)	2
5.	Assessment of land use and yield advantage (Rotational intensity, Croppingintensity, Diversity Index, Sustainable	2

	Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)	
6.	Estimation of protein content in pulses	1
7.	Planning and layout of field experiments	1
8.	Judging of physiological maturity in different crops	1
9.	Intercultural operations in different crops	1
10.	Determination of cost of cultivation of different crops	1
11.	Working out harvest index of various crops	1
12.	Study of seed production techniques in selected crops	1
13.	Visit of field experiments on cultural, fertilizer, weed control and watermanagement aspects	1
14.	Visit to nearby villages for identification of constraints in crop production	1
Total		**16**

Suggested Readings

1. *Das NR. 2007. Introduction to Crops of India. Scientific Publ.*
2. *Hunsigi G and Krishna KR. 1998. Science of Field Crop Production. Oxford & IBH.*
3. *Jeswani LM and Baldev B. 1997. Advances in Pulse Production Technology.ICAR.*
4. *Khare D and Bhale MS. 2000. Seed Technology. Scientific Publ.*
5. *Kumar Ranjeet and Singh NP. 2003. Maize Production in India: Golden Grain in Transition. IARI, New Delhi.*
6. *Pal M, Deka J and Rai RK. 1996. Fundamentals of Cereal Crop Production.Tata McGraw*
7. *Hill.*
8. *Prasad Rajendra. 2002. Text Book of Field Crop Production. ICAR.*
9. *Singh C, Singh P and Singh R. 2003. Modern Techniques of Raising FieldCrops. Oxford & IBH.*
10. *Singh SS. 1998. Crop Management. Kalyani.*
11. *Yadav DS. 1992. Pulse Crops. Kalyani.Prentice Hall.*

Ph.D. Programme

AGRON 611 CURRENT TRENDS IN AGRONOMY 3(3+0)

Theory

Unit I

Agro-physiological basis of variation in yield, recent advances in soilplant-water relationship.

Unit II

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 III

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.

Unit IV

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

Unit V

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.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Agro-physiological basis of variation in yield	2
2.	Recent advances in soilplant-water relationship	3
3.	Globalization of agriculture and WTO	3
4.	Precision agriculture	2
5.	Contract farming	2
6.	Organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming	3
7.	Crop residue management in multiple cropping systems	2
8.	Latest developments in plant management, weed management, cropping systems, grassland management, agro-forestry, allelopathy	3
9.	Mechanization in crop production: modern agricultural precision tools and technologies,	3
10.	GIS, GPS and remote sensing for crop management	3
11.	Global warming	2
12.	GM crops	2
13.	Seed production technology, seed certification, seed multiplication, hybrid seed production etc.	3
14.	Concepts of system approach in agriculture	3
15.	Holistic approach of farming systems	2
16.	Dryland farming	3
17.	Sustainable agriculture	2

18.	Research methodology in Agronomy	2
19.	Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues	3
Total		**48**

Suggested Readings

1. *Agarwal RL. 1995. Seed Technology. Oxford & IBH.*
2. *Dahiya BS and Rai KN. 1997. Seed Technology. Kalyani.*
3. *Govardhan V. 2000. Remote Sensing and Water Management in Command Areas:*
4. *Agroecological Prospectives. IBDC.*
5. *ICAR. 2006. Hand Book of Agriculture. ICAR.*
6. *Narasaiah ML. 2004. World Trade Organization and Agriculture. Sonali Publ.*
7. *Palaniappan SP and Annadurai K. 2006. Organic Farming - Theory and Practice. Scientific Publ.*
8. *Sen S and Ghosh N. 1999. Seed Science and Technology. Kalyani.*
9. *Tarafdar JC, Tripathi KP and Kumar M. 2007. Organic Agriculture Scientific Publ.*
10. *Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. A Text Book of Seed Technology. Kalyani Publication.*
11. *Reddy SR and Prabhakara G. 2015. Dryland Agriculture. Kalyani Publishers.*
12. *Gururajan B, Balasubhramanian R and Swaminath V. 2013. Recent Strategies on Crop Production. Kalyani Publishers.*
13. *Venkateswarlu B and Shanker Arun K. 2009. Climate change and agriculture: Adaptation and mitigation strategies. Indian Journal of Agronomy **54**(2): 226-230.*

AGRON 612 RECENT TRENDS IN CROP GROWTH AND PRODUCTIVITY 3(2+1)

Theory

Unit I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

Unit II

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 rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

Unit III

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; heat unit concept of crop maturity: concept and types of heat units.

Unit IV

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

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Plant density and crop productivity	1
2.	Plant and environmental factors, yield, plant distribution,	1
3.	Strategies for maximizing solar energy utilization; leaf area, interception of solar radiation and crop growth	2
4.	Photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis	1
5.	Difference in photosynthetic rates among and within species	1
6.	Physiological limitations to crop yield	1
7.	Solar radiation concept and agro-techniques for harvesting solar radiation	2
8.	Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR	2
9.	Validity and Limitations in interpreting crop growth and development	1
10.	Growth curves: sigmoid, linear, polynomial, parabolic and asymptotic,	2
11.	Root systems; root-shoot relationship	1
12.	Principles involved in inter and mixed cropping systems under rainfed and irrigated conditions	1
13.	Concept and differentiation of inter and mixed cropping	1
14.	Criteria in assessing the yield advantages	1
15.	Competitive relationship and competition functions	2
16.	Biological and agronomic basis of yield advantage under intercropping	1
17.	Physiological principles of dry land crop production, constraints and remedial measures	2
18.	Heat unit concept of crop maturity: concept and types of heat units viz. remainder index, degree days, physiological index and interrelationship	2
19.	Concept of plant ideotypes: crop physiology and new ideotypes	2
20.	Characteristics of ideotype for wheat, rice, maize, Pearlmillet, chickpea etc.	2
21.	Concept and types of growth hormones; their role in field crop	2

	production	
22.	Efficient use of resources	1
Total		**32**

Practical

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

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Field measurement of root-shoot relationship in crops at different growth stages	2
2.	Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., atdifferent stages of crop growth	2
3.	Computation of harvest index of various crops	2
4.	Assessment of crop yield on the basis of yield attributing characters	2
5.	Construction of crop growth curves based on growth analysis data	2
6.	Computation of competition functions, viz. LER, IER, aggressivity, competition indexetc. in intercropping	2
7.	Senescence and abscission indices	2
8.	Analysis of productivity trend in un-irrigated areas	1
9.	Analysis of productivity trend in irrigated areas	1
Total		**16**

Suggested Readings

1. *Chopra VL and Paroda RS. 1984. Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants. Oxford & IBH.*
2. *Delvin RM and Vitham FH. 1986. Plant Physiology. CBS Publ.*
3. *Evans LT. 1975. Crop Physiology. Cambridge Univ. Press.*
4. *Evans LT. 1996. Crop Evolution, Adaptation and Yield. Cambridge Univ. Press.*

5. *Gupta US. (Ed.). 1995. Production and Improvement of Crops for Drylands. Oxford & IBH.*
6. *Gupta US. 1988. Progress in Crop Physiology. Oxford & IBH.*
7. *Kramer PJ and Boyer JS. 1995. Water Relations of Plant and Soils. Academic Press.*
8. *Mukherjee S and Ghosh AK. 1996. Plant Physiology. Tata McGraw Hill.*
9. *Narwal SS, Politycka B and Goswami CL. 2007. Plant Physiology: Research Methods.Scientific Pub.*
10. *Tiaz L. and Zeiger E. 2006. Plant Physiology. Sinauer Associates, Inc.*

AGRON 621 RESEARCH AND PUBLICATION ETHICS 2 (2+0)

Theory

Unit I

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

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

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

Unit IV

Publication ethics: Definition, 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 behavior and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V

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 VI

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 VII

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.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Introduction to philosophy: definition, nature and scope, concept, branches	2
2.	Ethics: definition, moral philosophy, nature of moral judgements and reactions	2
3.	Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity	2
4.	Scientific misconducts-falsifications,fabrications and plagiarism (FFP)	2
5.	Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data	2
6.	Publication ethics: Definition, introduction and importance	2
7.	Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest	2
8.	Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, type, violation of publication ethics, authorship and contributor ship	3
9.	Identification of publication misconduct, complaints and appeals, predatory publishers and journals	2
10.	Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies	2
11.	software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggester, etc	3
12.	Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad	2
13.	Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools	2
14.	Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc.	2
15.	Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics.	2
Total		**32**

AGRON 622 RECENT TRENDS IN WEED MANAGEMENT 2(2+0)

Theory

Unit I

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 II

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

Unit III

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.

Unit IV

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

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registrationprocedures.

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and allele-herbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film,etc.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Crop-weed competition in different cropping situations	1
2.	Changes in weed flora, various causes and effects	1
3.	Different methods of weed management	2
4.	Migration, introduction, adaptation of weeds, Invasive weeds – biology and management	2
5.	Different mechanisms of invasion – present status and factors influencing weed invasion	1
6.	Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action	2
7.	Selectivity of herbicides and factors affecting them	2
8.	Climatic factors and phytotoxicity of herbicides	1
9.	Fate of herbicides in soil and factors affecting them	2
10.	Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites	2
11.	Residue management of herbicides	1
12.	Adjuvants -their types and significance in herbicide application	2
13.	Advances in herbicide products and application techniques and	2

	methods	
14.	Herbicide resistance	1
15.	Antidotes and crop protection compatibility of herbicides of different groups	1
16.	Compatibility of herbicides with other pesticides	1
17.	Herbicide rotation and herbicide mixtures	1
18.	Development of transgenic herbicide resistant crops	1
19.	Herbicide development, registrationprocedures	1
20.	Relationship of herbicides with tillage, fertilizer, irrigation, cropping system	1
21.	Bioherbicides, allelochemical and allele-herbicides, herbicide bioassays	2
22.	Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film,etc	2
Total		32

Suggested Readings

1. *Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.*
2. *Das TK. 2008. Weed Science: Basics and Applications, Jain Brothers (New Delhi)*
3. *Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.*
4. *Gupta OP. 2007. Weed Management: Principles and Practices, 2nd Ed.*
5. *Jugulan M, (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press*
6. *Monaco TJ, Weller SC and Ashton FM. 2014. Weed Science Principles and Practices, Wiley*
7. *Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.*
8. *Walia US. 2006. Weed Management, Kalyani.*
9. *Zimdahl RL. (ed). 2018. Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub*

AGRON 623 IRRIGATION MANAGEMENT 2(2+0)

Theory

Unit I

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 II

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 III

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 IV

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 V

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

Unit VI

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 VII

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 VIII

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 IX

Economic analysis of irrigation and cop planning for optimum use of irrigation water

Unit X

Crop water production function

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	Global water resources	1
2.	Water resources of India, irrigation projects during pre and post independence period and their significance in crop production	2
3.	irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need	2
4.	Water deficits and crop growth	1
5.	Movement of water in soil-water movement under saturated	1

	and unsaturated conditions,	
6.	Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil	2
7.	Soil-plant-water relationships	1
8.	Evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity	2
9.	factors affecting ET, control of ET by mulching and use of anti-transpirents	2
10.	Water requirement and factors affecting it.	1
11.	Infiltration,water use efficiency, management practices for improving water use efficiency of crops	2
12.	Soil and plant water potential, SPAC	1
13.	Crop water stress –water deficits and crop growth, adoptability to the crops	1
14.	Application of irrigation water, conveyance and distribution system, irrigation efficiency	2
15.	Agronomic considerations in the design and operation of irrigation projects	1
16.	Characteristics of irrigation and farming systems affecting irrigation management	1
17.	Strategies of using limited water supply	1
18.	Water availability with relation to nutrient availability	1
19.	Fertilizer use in relation to irrigation, optimizing the use of given irrigation supplies	1
20.	Land suitability for irrigation, land irrigability classification	1
21.	Integrated water management in command areas, institution of water management in commands, farmer's participation in command areas	2
22.	Irrigation legislation	1
23.	Economic analysis of irrigation and cop planning for optimum use of irrigation water	1
24.	Crop water production function	1
Total		**32**

Suggested Readings

1. *MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers*
2. *FAO. 1984. Irrigation Practice and Water Management. Oxford & IBH.*
3. *Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.*
4. *Mishra RR and Ahmad M. 1987. Manual on Irrigation and Agronomy. Oxford & IBH.*
5. *Panda SC. 2003. Principles and Practices of Water Management. Agrobios.*

6. *Reddy SR. 2000. Principles of Crop Production. Kalyani.*
7. *Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water.*
8. *In: Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.*
9. *Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH*

BIOCHEMISTRY

Semester Wise Distribution of Courses

S.No.	Course No.	Title of Course	Credit Hrs.
M. Sc (Ag.) Semester-I			
1.	BIOCHEM- 511	PLANT BIOCHEMISTRY	3 (2+1)
2	BIOCHEM- 512	ENZYMOLOGY	3 (2+1)
3.	BIOCHEM- 513	INTERMEDIARY METABOLISM	2 (2+0)
Minor Courses			
5.			2(2+0)
Supporting Courses			
6.	STAT-511	STATISTICAL METHOD FOR APPLIED SCIENCES	3(2+1)
Common Courses			
7.	PGS-511	LIBRARY AND INFORMATION SERVICES	1(0+1)
Total			14
Semester-II			
1.	BIOCHEM- 521	BASIC BIOCHEMISTRY	3 (2+1)
2.	BIOCHEM -522	TECHNIQUES IN BIOCHEMISTRY	3(1+2)
3.	BIOCHEM -523/ BIOCHEM -524	MOLECULAR BIOLOGY/ ANIMAL BIOCHEMISTRY	3 (2+1)/ 3 (3+0)
Minor Courses			
4.			3(2+1)
Supporting Courses			
5.	STAT-521	EXPERIMENTAL DESIGN	3(2+1)
Total			15
Semester-III			
1.	BIOCHEM -532/	BIOCHEMISTRY OF XENOBIOTICS/	2(2+0)/3

	BIOCHEM- 534/ BIOCHEM-533	**NUTRITIONAL BIO CHEMISTRY/IMMUNO CHEMISTRY**	**3(2+1)/ 3(3+0)**
Minor Courses			
2.	**GPB-531**	**MOLECULAR BREEDING AND BIOINFORMATICS**	**3(2+1)**
Common Courses			
3	**PGS- 531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
	BIOCHEM -543	**RESEARCH**	**30**
Semester-IV			
1	**BIOCHEM- 541**	**SEMINAR**	**1 (0+1)**
2	**BIOCHEM- 542**	**COMPREHENSIVE**	**NC**
3	**BIOCHEM -543**	**RESEARCH**	**30**

Note:M. Sc. Programme is deferred and course No. Biochem 511& 531 as Minor, Biochem 521 & 522 offered as supportingcourses and PG 533 as Common course

BIOCHEM-531 approved for Ph. D. Course.

M.Sc.(Ag.) Programme

BIOCHEM-511PLANT BIOCHEMISTRY 3(2+1)

Theory

BLOCK 1: PHOTOSYNTHESIS

Unit 1: Photosynthetic machinery:

Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis.

Unit 2: Photosynthesis – the process

Carbon reduction inC3, C4 and CAM plants, photorespiration, sucrose-starch interconversion.

BLOCK 2: CONVERSION OF PHOTOSYNTHATES

Unit 1: Synthesis of major biomolecules

Biosynthesis of structural carbohydrates, storage proteins and lipids.

Unit 2: Nitrogen and sulphur metabolism

Basic concepts of nitrogen and sulphur metabolism: biological nitrogen fixation, nitrate assimilation in plants, sulphur chemistry and function, reductive sulphate assimilation pathway, sulphated compounds.

BLOCK 3: GROWTH AND DEVELPOMENT

Unit 1: Germination and fruit ripening

Biochemistry of seed germination – stages, requirements, metabolism and mobilization of Storage material; Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.

Unit 2: Phytohormones

Different classes of phytohormones, their biosynthesis and mode of action.

BLOCK 4: SECONDARY METABOLITES

Unit 1: Biochemistry of plant secondary metabolites

Biochemistry and significance of plant secondary metabolites - phenolics, terpenoids, alkaloids,cyanogenic glycosides and glucosinolates, effect of biotic and abiotic factors on plant metabolism and plant defense system.

Lecture Schedule –Theory

S. No.	Topics	No. of Lectures
1	**Unit 1: Photosynthetic machinery:** Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis.	3
2	**Unit 2: Photosynthesis – the process:** Carbon reduction inC_3, C_4 and CAM plants, photorespiration, sucrose-starch interconversion.	4

3	**Unit 1: Synthesis of major biomolecules** : Biosynthesis of structural carbohydrates, storage proteins and lipids.	5
5	**Unit 2: Nitrogen and sulphur metabolism:** Basic concepts of nitrogen and sulphur metabolism : biological nitrogen fixation, nitrate assimilation in plants, sulphur chemistry and function, reductive sulphate assimilation pathway, sulphated compounds.	5
6	**Unit 1: Germination and fruit ripening:** Biochemistry of seed germination – stages, requirements, metabolism and mobilization of storage material; Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.	4
7	**Unit 2: Phytohormones:** Different classes of phytohormones, their biosynthesis and mode of action.	5
8	**Unit 1: Biochemistry of plant secondary metabolites:** Biochemistry and significance of plant secondary metabolites - phenolics, terpenoids, alkaloids, cyanogenic glycosides and glucosinolates, effect of biotic and abiotic factors on plant metabolism and plant defense system.	6
Total		**32**

PracticalSchedule-Practical

S. No.	Topics	No. of Lectures
1	Fractionation of cell organelles.	1
2	Estimation of starch.	1
3	Assay of ADPG pyrophosphorylase/starch synthase.	2
4	Assay of PAL/SOD.	2
5	Assay of PPO/LOX.	2
6	Estimation of individual amino acids.	1
7	Qualitative tests of secondary metabolites (alkaloids, sterols etc.).	1
8	Content and composition of carotenoids, anthocyanin and chlorophylls.	1
9	Determination of polyphenols/phenolics.	1
10	Estimation of glucosinolates.	1
11	Estimation of cyanogenic compounds.	2
12	Fractionation of storage proteins.	1
Total		**16**

Suggested Readings

1. *Buchannan,B.B.,Gruissem,W.andJones,R.L.(eds.).2000.BiochemistryandMolecularBiology ofPlants.2nd edition.WILEYBlackwell*
2. *Heldt,H-W.2010.PlantBiochemistryandMolecularBiology.4th ed.OxfordUniversityPress*
3. *GoodwinTW&MercerEI.2005.IntroductiontoPlantBiochemistry.2nd edition.CBS*
4. *Heldt,H-W.andPiechulla,B.2010.PlantBiochemistry.4th Edition.Elsevier*
5. *Harinda,MakkeaandKlaus.2007.PlantSecondaryMetabolites.Springer*
6. *LelandJ.Cseke,AraKirakosyan,PeterB.Kaufman,SaraWarber,JamesA.Duke,HarryL.Brie lmann.2006.NaturalProductsfromPlants.2nd Edition.CRCPress*

BIOCHEM-512ENZYMOLOGY 3 (2+1)

Objectives

Toimpartknowledgeaboutthecatalyticroleofenzymes,theirstructure,physico-chemical,kineticandregulatorypropertiesandmechanismofaction.

Theory

BLOCK1:INTRODUCTIONTOENZYMES

Unit1:Structureandfunctionofenzyme:

Historicperspective,generalpropertiesofenzymes,enzymecompartmentalizationincellorganelles, nomenclatureandclassificationofenzymes,ribozymes,isozymes,abzymes.

Unit2:Extractionandpurificationofenzymes: Extractionofsolubleandmembrane-boundenzymes,purificationofenzymes,measurementofenzymeactivity.

BLOCK2:ENZYMESTRUCTUREANDFUNCTION

Unit1:Chemicalnatureofenzyme:

Enzymespecificity,monomericandoligomericenzymes,catalyticmechanism,mechanismofenzyme action,pseudoenzymes,enzymepromiscuity.

Unit2:Cofactorsandcoenzymes: Chemical nature and involvement of cofactors and coenzymes in enzyme catalyzed reactions,metalactivatedenzymesandmetalloenzymes,mechanismofenzymecatalyzedreactionswithoutcofactors.

Unit3:Natureofactivesite: Activesite,identificationofbindingsitesandcatalyticsites.

BLOCK3.ENZYMEKINETICS

Unit1:Singlesubstratekinetics:

Relationshipbetweeninitialvelocityandsubstrateconcentration,Michaelis-Mentenequation,Lineweaver-BurkandEadie-Hofsteeplots,analysisofkineticdata,numericalexercises.

Unit2:Enzymeinhibition: Reversibleandirreversibleenzymeinhibition,usesofenzymeinhibition.

Unit3:Kineticsofallostericenzymes: Nature of allosteric enzymes, sigmoidal kinetics, MWC model and allosteric regulation, KNFmodelandallostericregulation.

Unit4:Regulationofenzymeactivity:
Feedbackregulation,regulatoryenzymes,controlofenzymaticactivity,symmetryandsequentialmodel,reversible covalentmodificationofenzymes.

BLOCK4:APPLICATIONOFENZYMOLOGY

Unit1:Industrialapplicationofenzymes:
Industrialapplicationofenzymecatalysisinsectorslikefoodprocessing,detergents,biofuels,paperandpulp,biosensorsandclinicalapplicationsofenzymes.

Unit2:Biotechnologicalapplicationofenzymes:
Largescaleproductionandpurificationofenzymes,immobilizationofenzymes.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Historicperspective,generalpropertiesofenzymes,enzymecompartmentalizationincell organelles,nomenclatureandclassificationofenzymes,ribozymes,isozymes,abzymes.	3
2	Extractionofsolubleandmembrane-boundenzymes,purificationofenzymes,measurementofenzymeactivity.	2
3	Enzymespecificity,monomericandoligomericenzymes,catalyticmechanism,mechanismofenzymeaction,pseudoenzymes,enzymepromiscuity.	3
4	Chemical nature and involvement of cofactors and coenzymes in enzyme catalyzed reactions,metalactivatedenzymesandmetalloenzymes,mechanismofenzymecatalyzed reactionswithoutcofactors.	3
5	Activesite,identificationofbindingsitesandcatalyticsites.	2
6	Relationshipbetweeninitialvelocityandsubstrateconcentration,Michaelis-Mentenequation,Lineweaver-BurkandEadie-Hofsteeplots,analysisofkineticdata,numericalexercises.	4
7	Reversibleandirreversibleenzymeinhibition,usesofenzymeinhibition.	3
8	Nature of allosteric enzymes, sigmoidal kinetics, MWC model and allosteric regulation, KNFmodelandallostericregulation.	3
9	Feedbackregulation,regulatoryenzymes,controlofenzymaticactivity,symmetryandsequentialmodel,reversible covalentmodificationofenzymes.	4

10	Industrialapplicationofenzymecatalysisinsectorslikefoodprocessing,detergents,biofuels, paperandpulp,biosensorsandclinicalapplicationsofenzymes.	4
11	Largescaleproductionandpurificationofenzymes,immobilizationofenzymes.	3
Total Classes		**34**

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Solubleproteinestimation.	2
2	Enzymeassaybytakinganymodelenzyme.	1
3	Isolationandpurificationofanymodelenzyme.	2
4	Studyoftheeffectofenzymeandsubstrateconcentrationsonenzymeactivity.	2
5	Determination of K_m and V_{max}.	2
6	DeterminationofpHandtemperatureoptima.	1
7	Effectofinhibitorsonenzymeactivity.	2
8	DeterminationofpHandtemperaturestabilityofenzyme.	2
9	Electrophoreticanalysisofisozymes.	4
Total		**18**

Suggested Readings

1. *Palmer,T.andBonner,P.L.2007.Enzymes:Biochemistry,Biotechnology,ClinicalChemistry.2nd edition.WoodheadPublishing.*
2. *Okotore,R.O.2015.EssentialsofEnzymology.XLIBRIS*
3. *Herald,J.2016.EssentialsofEnzymology.SyrawoodPublishingHouse*
4. *Suzuki,H.2015.HowEnzymesWork:FromStructuretoFunction.JennyStanfordPublishing.*
5. *Bugg,T.D.H.2012.IntroductiontoEnzymeandCoenzymeChemistry,3rd Edition.WILEY*
6. *Guo,Y.2014.EnzymeEngineering.SciencePress*
7. *Bisswanger,H.2011.PracticalEnzymology.Wiley-Blackwell*

BIOCHEM-513 INTERMEDIARY METABOLISM 2 (2+0)

Objectives

Thecourseisdesignedtogiveaninsightintothedifferentmetabolicpathways,theirinterrelationship,regulation,metabolicdisordersinhumanandpathwayengineeringinplant

Theory

BLOCK1:INTRODUCTIONTOMETABOLISM

Unit1:Overviewofmetabolism: Thelivingcell-auniquechemicalsystem,biochemicalreactiontypes,bioenergetics,bioavailabilityofnutrients,transportmechanism,signaltransduction.

BLOCK2:METABOLISMOFENERGYNUTRIENTS

Unit1:Carbohydratemetabolism:

Majorcatabolicandanabolicpathwaysofcarbohydratemetabolism,theglyoxylatepathway.

Unit2:Lipidmetabolism:

Fattyacidoxidation,ketonebodies,fattyacidbiosynthesis,synthesisoftriacylglycerols,cholesterol,eicosanoids.

Unit3:Proteinmetabolism:

Generalreactionsofaminoacidmetabolism,degradativeandbiosyntheticpathwaysofaminoacids,Ureacycle,aminoacidsasmetabolicprecursors.

Unit4:Energytransductionandoxidativephosphorylation:

Mechanismsofenergytransduction,electrontransportsystem,oxidativephosphorylation,controlofATPproduction.

BLOCK3.NUCLEOTIDEMETABOLISM

Unit1:Nucleotidemetabolism: Synthesisanddegradationofpurineandpyrimidinenucleotides.

BLOCK4:METABOLICREGULATIONANDDEFECTSINMETABOLISM

Unit1:Regulationofmetabolicpathways:

Regulation of carbohydrate, lipid, protein, nucleotide metabolism and oxidativephosphorylation.

Unit2:Defectsinmetabolism:

Disordersofcarbohydrates,lipids,aminoacidsandnucleicacidmetabolism,andinbornerrorsofmetabolism.Metabolicpathwayengineering.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Thelivingcell-auniquechemicalsystem,biochemicalreactiontypes,bioenergetics,bioavailabilityofnutrients,transportmechanism,signaltransduction.	4
2	Majorcatabolicandanabolicpathwaysofcarbohydratemetabolism,theglyoxylatepathway	5
3	Fattyacidoxidation,ketonebodies,fattyacidbiosynthesis,synthesisoftriacylglycerols, cholesterol,eicosanoids.	5
4	Generalreactionsofaminoacidmetabolism,degradativeandbiosyntheticpathwaysofaminoacids,Ureacycle,aminoacidsasmetabolicprecursors.	5
5	Mechanismsofenergytransduction,electrontransportsystem,oxidativephosphorylation,controlof ATPproduction.	4
6	Synthesisanddegradationofpurineandpyrimidinenucleotides.	3
7	Regulation of carbohydrate, lipid, protein, nucleotide metabolism and oxidativephosphorylation.	4
8	Disordersofcarbohydrates,lipids,aminoacidsandnucleicacidmetabolism,andinbornerrorsofmetabolism.Metabolicpathwayengineering.	4
Total		**34**

Suggested Readings

1. *Nelson,D.L.andCox, M.M.2017.LehningerPrinciples ofBiochemistry.7th edition.W.H.Freeman&CoLtd*
2. *Satyanarayana,U.andChakrapani,U.2017.Biochemistry.5thedition,Elsevier*
3. *CampbellM.K.andFarrellS.O.2009.Biochemistry.6theditionThomsonHigher Education.*
4. *MoranL.A.,HortonH.R.,ScrimgeourK.G.andPerry,M.D.2012.Principlesof Biochemistry.5theditionPearson,*
5. *Voet,D.andVoetJ.G.2011.Biochemistry.4thedition.JohnWiley.*
6. *Pratt,C.W.andCornely,K.2014.EssentialBiochemistry.3rdEdition.Wiley*
7. *Moorthy,K.2007.FundamentalsofBiochemicalCalculations.2ndedition.CRC Press.*

BIOCHEM-532 BIOCHEMISTRY ONXENOBIOTICS2 (2+0)

Objectives

To impart knowledge on xenobiotics and the mechanism of their metabolism and detoxification in living system.

Theory

BLOCK1: BIOCHEMISTRYONXENOBIOTICS

Unit1: Xenobiotics: Xenobiotics:classificationandtheireffectsonbiologicalsystems,Problemsrelatedtoxenobiotics degradation,potential effects of toxic agents on immune system function, bioticmetabolismof xenobiotics-biodegradation/biotransformation.

Unit2:Modeofdegradation: Mode of degradation - Enzymatic and Non-enzymatic, Metabolism of toxic compounds withreferencetoroleofdetoxifyingenzymes,Mechanismofxenobioticsdetoxification-inanimalusingtheenzymesofPhaseIandPhaseII,Roleofmicrobesinxenobioticsdegradation and co-metabolism, Biodegradation and its genetics, manipulation of xenobioticdegradative genes.

Unit3:Plantmetabolismofxenobiotics: Plantmetabolismofxenobiotics-transformation,conjugationandcompartmentation,Metabolicresponsesofpesticidesinplants,Impact,metabolism,andtoxicityofheavymetalsinplants,Regulationofxenobioticsinhigherplants:signalling anddetoxification.

Unit4:Phytoremediation:

Phytoremediation,Advancesindevelopmentoftransgenicplantsforremediationofxenobioticpollutants,safety assessmentofxenobiotics.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	**Unit1:Xenobiotics**: Xenobiotics:classificationandtheireffectsonbiologicalsystems,Problemsrelatedtoxenobiotics degradation,potential effects of toxic agents on immune system function, bioticmetabolismof xenobiotics-biodegradation/biotransformation.	8
2	**Unit2:Modeofdegradation**: Mode of degradation - Enzymatic and Non-enzymatic, Metabolism of toxic compounds withreferencetoroleofdetoxifyingenzymes,Mechanismofxenobioticsdetoxification-inanimalusingtheenzymesofPhaseIandPhaseII,Roleofmicrobesinxenobioticsdegradation and co-metabolism, Biodegradation and its genetics, manipulation of xenobioticdegradative genes.	8
3	**Unit3:Plantmetabolismofxenobiotics**: Plantmetabolismofxenobiotics-transformation,conjugationandcompartmentation,Metabolicresponsesofpesticidesinplants,Impact,metabolism,andtoxicityofheavymetalsinplants,Regulationofxenobioticsinhigherplants:signallinganddetoxification.	8
4	**Unit4:Phytoremediation:** Phytoremediation,Advancesindevelopmentoftransgenicplantsforremediationofxenobioticpollutants,safety assessmentofxenobiotics.	10
Total Classes		**34**

Suggested Readings

1. *Richardson,M.1996.EnvironmentalXenobiotics.CRCPress*
2. *Singh,A.,Prasad,S.M.andSingh,R.P.(eds).2016.PlantResponsestoXenobiotics.Springer.*
3. *Chang,Y-C.(ed).2019.MicrobialBiodegradationofXenobioticCompounds.CRCPress*
4. *CostasIoannides(ed).2002.EnzymeSystemsthatMetaboliseDrugsandOtherXenobiotics.WILEY*
5. *Lee,P.,,Aizawa,H.,Gan,L.,Prakash,C.AndZhong,D.2014.HandbookofMetabolicPathwaysofXenobiotics.WILEY*
6. *Emerson,M.L.2012.Xenobiotics:NewResearch.NovaScience*
7. *Shamaan,N.A.2008.Biochemistryofxenobiotics:towardsahealtylifestyleandsafeenvironment.PenerbitUniversitiPutraMalaysia.*

BIOCHEM-521 BASIC BIOCHEMISTRY 3 (2+1)

Objectives

The course is designed to provide elementary knowledge/overview of structure and function of proteins, carbohydrates, lipids, nucleic acids and other biomolecules and their metabolism**.**

Theory

BLOCK1:INTRODUCTIONTOBIOCHEMISTRY

Unit1:ScopeandimportanceofBiochemistry:

Biochemistryasmodernscienceanditsvariousdivisions,ScopeandimportanceofBiochemistryinagricultureandalliedsciences.

Unit2:Foundationoflife:

Fundamentalprinciplesgoverninglife,supramolecularstructures,significanceofweaknoncovalentinteractionsinbiology

Unit3:Water: Structure of water, ionization of water, acid base concept, pH and buffers, significance ofstructure-functionrelationship

BLOCK2:STRUCTUREANDFUNCTIONOFBIOMOLECULES

Unit1:Biomolecules:

Structure,classification,propertiesandfunctionofcarbohydrates,aminoacids,proteins,lipidsandnucleicacids.

Unit2:Plantsecondarymetabolites:

Structure,classificationandfunctionofplantsecondarymetabolites.

BLOCK3:METABOLISM–THEBASICS

Unit1:Moleculesaidingmetabolism: Structure and biological functions of vitamins and coenzymes, enzymes: classification andmechanismof action;regulation,factorsaffectingenzymeaction.Hormones:animal andplants.

Unit2:Thermodynamics–principlesandenergeticoflife

Fundamentalsofthermodynamicprinciplesapplicabletobiologicalprocesses,Bioenergetics.

BLOCK4:CATABOLISMANDITSREGULATION

Unit1:Catabolismofenergymolecules:

Importantandbasicdegradativemetabolicpathwaysofcarbohydrates,lipidsandproteinsandtheirregulation.

Unit2:ATPformation:

FormationofATP,substratelevelphosphorylation,electrontransportchainandoxidativephosphorylation,chemiosmotictheoryandprotonmotiveforce.

BLOCK5:FUNDAMENTALSOFMOLECULARBIOLOGYANDGENETICENGINEERING.

Unit1:Molecularbiologyprocesses Overviewofreplication,transcriptionandtranslation

Unit2:RecombinantDNAtechnology:

Restrictionenzymes,DNAcloning,applicationsofcloning,transgenics

Lectures Schedule-Theory

S No.	Topics	No. of Lectures
1	Biochemistryasmodernscienceanditsvariousdivisions,ScopeandimportanceofBiochemistryinagricultureandalliedsciences.	1
2	Fundamentalprinciplesgoverninglife,	2

	supramolecularstructures,significanceofweaknoncovalentinteractionsinbiology.	
3	Structure of water, ionization of water, acid base concept, pH and buffers, significance ofstructure-functionrelationship.	2
4	Structure,classification,propertiesandfunctionofcarbohydrates.	2
5	Structure,classification,propertiesandfunctionofaminoacids.	2
6	Structure,classification,propertiesandfunctionofproteins.	2
7	Structure,classification,propertiesandfunctionoflipids.	2
8	Structure,classification,propertiesandfunctionofnucleicacids.	2
9	Structure,classificationandfunctionofplantsecondarymetabolites-Phenolics.	1
10	Structure,classificationandfunctionofplantsecondarymetabolites-Terpenes.	1
11	Structure,classificationandfunctionofplantsecondarymetabolites-N-Containing compounds, Alkaloids & others.	2
12	Structure and biological functions of vitamins and coenzymes, enzymes: classification andmechanismof action;regulation,factorsaffectingenzymeaction.Hormones:animal andplants.	2
13	Fundamentalsofthermodynamicprinciplesapplicabletobiologicalprocesses,Bioenergetics.	2
14	Importantandbasicdegradativemetabolicpathwaysofcarbohydrates andtheirregulation.	2
15	Importantandbasicdegradativemetabolicpathwaysoflipidsandtheirregulation.	1
16	Importantandbasicdegradativemetabolicpathwaysofproteinsandtheirregulation.	1
17	FormationofATP,substratelevelphosphorylation,electrontransportchainandoxidativephosphorylation,chemiosmotictheoryandprotonmotiveforce.	2
18	Overviewofreplication,transcriptionandtranslation	1
19	Restrictionenzymes,DNAcloning,applicationsofcloning,transgenics.	2
Total		**32**

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Preparationofstandardandbuffersolutions.	1
2	Detectionofcarbohydrates,aminoacidsandproteins.	1
3	Extractionandestimationofsugars.	1
4	Extractionandestimationofaminoacids.	2
5	Extractionandestimationofproteins.	2
6	Estimationofacidvalueoffat/oil.	1
7	Estimationofperoxidevalueoffat/oil.	1

8	Estimationofsaponificationvalueinfatsandoils.	1
9	Fattyacidcompositioninfat/oilbyGC.	1
10	EstimationofDNAandRNAbyspectroscopicmethods.	1
11	EstimationofAscorbicacid.	2
12	SeparationofbiomoleculesbyTLCandPaperchromatography.	1
13	Estimationofalphaamylaseactivity.	1
14	Qualitativetestsforsecondaryplantmetabolites.	2
Total Classes		**18**

Suggested Readings

1. *Nelson,D.L.andCox,M.M.2017.LehningerPrinciplesofBiochemistry.7th edition.*
2. *W.H.Freeman&CoLtd*
3. *Satyanarayana,U.andChakrapani,U.2017.Biochemistry.5th edition,Elsevier.*
4. *MoranL.A.,HortonH.R.,ScrimgeourK.G.andPerry,M.D.2012.PrinciplesofBiochemistry.5th editionPearson,*
5. *Voet,D.andVoetJ.G.2011.Biochemistry.4th editionJohnWiley.*
6. *Pratt,C.W.andCornely,K.2014.EssentialBiochemistry.3rd Edition.Wiley*
7. *Moorthy,K.2007.FundamentalsofBiochemicalCalculations.2nd edition.CRCPress*
8. *ConnE.E.,Stumpf,P.K.,Bruening,G.andDoi,R.H.(2006).OutlinesofBiochemistry.5th edition.Wiley*
9. *Mittal, G. K. (2021). Practical manual, Fundamentals of Plant Biochemistry & Biotechnology.*

BIOCHEM-522TECHNIQUES IN BIOCHEMISTRY3 (1+2)

Objectives

Toprovidehands-onexperiencetodifferentbiochemicaltechniquescommonlyusedinresearchalongwiththeknowledgeonprinciplesandtheinstrumentation**.**

Theory

BLOCK1:SEPARATIONTECHNIQUES

Principlesandapplicationsofseparationtechniques.

Unit1:Chromatographytechniques:

Principlesandapplicationsofpaper,thinlayer,gelfiltration,ion-exchange,affinity,column&HPTLC,GC,HPLCandFPLC.

Unit2: Electrophoretictechnique:

Generalprinciples,paperandgelelectrophoresis,nativeandSDS-PAGE,2D-PAGE,capillaryelectrophoresis.

Unit3: Centrifugation & Hydrodynamicmethods:

Basicprinciplesofsedimentation,type,careandsafetyaspectsofcentrifugepreparativeandanalytical centrifugation.

Hydrodyanmicmethodsofseparationofbiomoleculessuchasviscosityandsedimentationvelocity,-theirprinciples.

BLOCK2:SPECTROSCOPICTECHNIQUES

Unit1:Spectrophotometry: PrinciplesandapplicationsofUV-visible,Fluorescence,IRandFTIR,Raman,NMRandFTNMR,ESR andX-Rayspectroscopy.

Unit2:Massspectroscopy: MS/MS,LC-MS,GC-MS,MALDI-TOF,applicationsofmassspectrometryinbiochemistry.

Unit3:Atomicabsorptionspectrophotometry: Principle,functionandinstrumentationof atomicabsorptionspectrophotometry.

BLOCK3.MICROSCOPY

Unit1:Microscopictechniques: Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy,flow cytometry.

BLOCK4:TRACER,IMAGING,IMMUNOCHEMICALANDOTHERTECHNIQUES

Unit1:Tracertechnique: Tracer techniques in biology: concept of radioactivity, radioactivity counting methods withprinciples of different types of counters, concept of α, β and γ emitters, scintillation counters,γ-rayspectrometers,autoradiography,applicationsofradioactivetracersinbiology.

Unit2: Immunochemicaltechnique: Productionofantibodies,immunoprecipitation,immunoblotting,immunoassays,RIAandELISA.

Unit3:Othertechniques: Cryopreservation,polymerasechainreaction(PCR),FACS

Lectures Schedule-Theory

S. No.	Topics	No. of Lectures
1	Principlesandapplicationsofpaper,thinlayer,gelfiltration,ion-exchange,affinity,column&HPTLC,GC,HPLCandFPLC.	2
2	Generalprinciples, paperandgelelectrophoresis,nativeandSDS-PAGE,2D-PAGE,capillaryelectrophoresis.	2
3	Basicprinciplesofsedimentation,type,careandsafetyaspectsofcentrifugepreparative andanalyticalcentrifugation. Hydrodyanmicmethodsofseparationofbiomoleculessuchasviscosityandsedimentation velocity,-theirprinciples.	2
4	PrinciplesandapplicationsofUV-visible,Fluorescence,IRandFTIR,Raman,NMRandFTNMR,ESR andX-Rayspectroscopy.	1
5	MS/MS,LC-MS,GC-MS,MALDI-TOF,applicationsofmassspectrometryinbiochemistry.	2
6	Principle,functionandinstrumentationof atomicabsorptionspectrophotometry.	1
7	Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy,flow Cytometry.	1
8	Tracer techniques in biology: concept of radioactivity, radioactivity counting methods withprinciples of different types of counters, concept of α, β and γ emitters, scintillation counters,γ-rayspectrometers,autoradiography,applicationsofradioactivetracersinbiology.	2

9	Productionofantibodies,immuno precipitation,immuno blotting,immunoassays,RIAandELISA.	2
10	Cryopreservation,polymerasechainreaction(PCR),FACS	1
Total		**16**

Lectures Schedule-Practical

S. No.	Topics	No. of Lectures
1	Expressionofconcentrationintermsofdilution,molarity,normality,percente expression.	3
2	pHmeasurementandbufferpreparation.	2
3	Determinationofabsorptionmaximaofbiomolecules.	2
4	Estimationofbiomoleculesthroughspectrophotometryandothermethods.	3
5	Separationofcarbohydratesandaminoacidsbypaperchromatography.	3
6	Separationandanalysisoffattyacids/lipidsbyGC.	3
7	Separation/estimationofbiomoleculesthroughHPLCandFPLC.	4
8	Separationofproteinsusingionexchange,gelfiltrationandaffinitychromatography.	3
9	Electrophoreticseparationofproteinsandnucleicacids.	4
10	(NH4)2SO4precipitationanddialysis.	3
11	PCR	**2**
Total		**32**

Suggested Readings

1. *Boyer,R.2011.BiochemistryLaboratory:ModernTheoryandTechniques2nd Edition.Pearson.*
2. *Hofmann,A.andClokie,S.2010.WilsonandWalker'sPrinciplesandTechniquesofBiochemistryandMolecularBiology.7th edition.CambridgeUniversityPress.*
3. *SawhneySK&SinghR.2000.IntroductoryPracticalBiochemistry.2nd Ed.Narosa*
4. *Katoch,R.2011.AnalyticalTechniquesinBiochemistryandMolecularBiology.Springer*
5. *Boyer,R.2009.ModernExperimentalBiochemistry.Fifthimpression.Pearson*
6. *Lottspeich,F.andEngels,J.W.(Eds).2018.Bioanalytics:AnalyticalMethodsandConceptsinBiochemistryandMolecularBiology.Wiley-VCH*
7. *Wilson,K.andWalker,J.2010.PrinciplesandTechniquesofBiochemistryandMolecular Biology,7th Edition.CambridgeUniversityPress*

BIOCHEM-523 MOLECULAR BIOLOGY 3 (2+1)

Objectives

To provide knowledge of life processes at the molecular and cellular levels, including the storage, transfer and regulation of genetic information and specialist theoretical knowledge and practical experience of gene manipulation and the analysis of nucleic acids and proteins**.**

Theory

BLOCK1:INTRODUCTIONTONUCLEICACIDS

Unit1:History: Historicaldevelopmentofmolecularbiology,nucleicacidsasgeneticmaterial.

Unit2:Propertiesofnucleicacid: Nucleic acid structure, chemical and physical properties of nucleic acids, spectroscopic andthermalpropertiesofnucleicacids,DNAsupercoiling.

Unit3:Genesandgenome: Concept of genes and genome, genome complexity**,** genome organization in prokaryotes andeukaryotes,chromatinstructureandfunction,repetitiveandnon-repetitiveDNA,satelliteDNA centraldogma,genome editing.

BLOCK2:SYNTHESISOFNUCLEICACID

Unit1:DNAreplication: Modesof replication, DNA polymerases, topoisomerases, DNA ligase, model of replisome,semi conservative replication in prokaryotes and eukaryotes, inhibitors of replication, DNAdamageandrepair.

Unit2:Transcription:

Basicprinciplesoftranscription,transcriptioninitiation,elongationandtermination,RNAprocessing,RNAinterference,siRNAs,miRNAsandotherncRNAs,DNA/RNAediting.regulationoftranscription,reversetranscription.

BLOCK3.PROTEINSYNTHESIS

Unit1:Translationmachinery:

RibosomesstructureandfunctionorganizationofribosomalproteinsandRNAgenes,genetic code,aminoacyltRNAsynthases.

Unit2:Mechanismofproteinsynthesis:

Initiation,chainelongationandterminationoftranslation,energetics,inhibitorsoftranslation.

Unit3:Post-translationalevents:

Posttranslationalmodificationsofnascentpolypeptide,proteintargetingandturnover,regulationofgeneexpressioninprokaryotesandeukaryotes,nucleasesandrestrictionenzymes.

BLOCK4:GENEMANIPULATION

Unit1:DNAsequencing: Importance, Sanger method, High-Throughput Sequencing (HTS) techniques, applications ofDNA sequencing.

Unit2:RecombinantDNAtechnology: Vectors, isolation of genes,recombinants vector,selection ofrecombinants, characterizationand expression of clonedDNA, transformation, transgenesis, mutation, molecular mechanismofmutation,sitedirectedmutagenesis,*in vitro*mutagenesis.

Unit3:Techniquesinmolecularbiology:

Polymerasechainreaction(PCR),expressioncloning,gelelectrophoresis,molecularmarkers,macromoleculeblottingandprobing,arrays(DNAarrayandproteinarray)–principlesandapplication.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Historicaldevelopmentofmolecularbiology,nucleicacidsasgeneticmaterial.	1
2	Nucleic acid structure, chemical and physical properties of nucleic acids, spectroscopic andthermalpropertiesofnucleicacids,DNAsupercoiling.	3
3	Concept of genes and genome, genome complexity**,** genome organization in prokaryotes andeukaryotes,chromatinstructureandfunction,repetitiveandnon-repetitiveDNA,satelliteDNA centraldogma,genome editing.	3
4	Modesof replication, DNA polymerases, topoisomerases, DNA ligase, model of replisome,semi conservative replication in prokaryotes and eukaryotes, inhibitors of replication, DNAdamageandrepair.	4
5	Basicprinciplesoftranscription,transcriptioninitiation,elongationandtermination,RNAprocessing,RNAinterference,siRNAs,miRNAsandotherncRNAs,DNA/RNAediting.regulationoftranscription,reversetranscription.	3
6	RibosomesstructureandfunctionorganizationofribosomalproteinsandRNAgenes,genetic code,aminoacyltRNAsynthases.	3
7	Initiation,chainelongationandterminationoftranslation,energetics,inhibitorsoftranslation.	3
8	Posttranslationalmodificationsofnascentpolypeptide,proteintargetingandturnover,regulationofgeneexpressioninprokaryotesandeukaryotes,nucleasesandrestrictionenzymes.	4
9	Importance, Sanger method, High-Throughput Sequencing (HTS) techniques, applications ofDNA sequencing.	3
10	Vectors, isolation of genes,recombinants vector,selection ofrecombinants, characterizationand expression of clonedDNA, transformation, transgenesis, mutation, molecular mechanismofmutation,sitedirectedmutagenesis,*in vitro*mutagenesis.	5
11	Polymerasechainreaction(PCR),expressioncloning,gelelectrophoresis,molecularmarkers,macromoleculeblottingandprobing,arrays(DNAarrayandproteinarray)–principlesandapplication.	4
Total		**36**

Lecture Schedule-Practicals

S. No.	Topics	No. of Lectures
1	IsolationandpurificationofDNAandRNA.	3
2	TocheckthepurityofisolatedDNAandRNA.	1
3	RestrictionfragmentationofgenomicDNA.	2
4	Separationofoligosbyagarosegelelectrophoresis.	2
5	CloningofDNAfragmentinvector.	2
6	Selectionofrecombinant.	1
7	SSRanalysisofDNA.	3
8	cDNAsynthesisusingRT-PCR.	2
9	Basictoolsinbioinformaticsanalysis.	4
Total		**20**

Suggested Readings

1. *Snape,A.,Papachristodoulou,D.,Elliott,W.H.andElliott,C.2014.Biochemistry andMolecularBiology.OxfordUniversityPress*
2. *Krebs,J.E.,Goldstein,E.S.andKilpatrick,S.T.2018.Lewin'sGENESXII.Jones&BartlettLearning*
3. *Lodish,H.,Berk,A.,Kaiser,C.A.,Krieger,M.AndBretscher,A.2016.MolecularCellBiology. W HFreeman&Co.*
4. *Hoffmann,A.AndClokie,S.2018.WilsonandWalker'sPrinciplesandTechniquesofBiochemistryandMolecularBiology.CambridgeUniversityPress.*
5. *PrimroseSB,TwymanRMandOldRW.2002.PrinciplesofGeneManipulation:6thEd.Wiley*
6. *Karp,G.2013.CellandMolecularBiology.Wiley*
7. *Neidle,S.2008.PrinciplesofNucleicAcidStructure.ElsevierInc.*
8. *Watson,J.,Baker,T.A.,Bell,S.P.,Gann,A.,Levine,M.andLosick,R.2014.Molecularbiologyofthegene7th edition,Pearson*

BIOCHEM-524 ANIMAL BIOCHEMISTRY 3 (3+0)

Objectives

To impart knowledge regarding biochemistry of various physiological processes, specialized tissues and hormone action in animal system.

Theory

BLOCK1: ANIMALBIOCHEMISTRY

Unit1:Biochemistryofassimilation:

Digestionandabsorptionoffood,Detoxification,biochemistryofspecializedtissues– connectivetissue,skin,muscle,nervoustissueandbloodandotherbodyfluids.

Unit2:Nutrientsandtheirbiochemistry: Water, electrolyte and acid-base balance, structure, function and mechanism of major traceelements, vitamins, energy nutrients and biochemistry of respiration, bioactive peptides andfunctionaloligosaccharides.

Unit3:Hormonesandtheirrole:

Hormonesofthyroid,hypothalamus,pituitary,pancreas,adrenalsandsexhormones,Membranerecept orsofhormones,signaltransduction.

Unit4:Immunesystem: Immune systems, immunoglobulins, monoclonal antibodies, formation of antibody, antibodydiversity, complement system– classicaland alternate, major histocompatibility complexes,cellmediatedimmuneresponse,mechanismsofimmunity.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Digestionandabsorptionoffood,Detoxification,biochemistryofspecializedtissues– connectivetissue,skin,muscle,nervoustissueandbloodandotherbodyfluids.	12
2	Water, electrolyte and acid-base balance, structure, function and mechanism of major traceelements, vitamins, energy nutrients and biochemistry of respiration, bioactive peptides andfunctionaloligosaccharides.	12
3	Hormonesofthyroid,hypothalamus,pituitary,pancreas,adrenalsandsexhormones,Membranereceptorsofhormones,signaltransduction.	12
4	Immune systems, immunoglobulins, monoclonal antibodies, formation of antibody, antibodydiversity, complement system– classicaland alternate, major histocompatibility complexes,cellmediatedimmuneresponse,mechanismsofimmunity.	12
Total		**48**

Suggested Readings

1. *Bradley,A.2018.AnimalPhysiologyandBiochemistry.1stedition.EdtechPress*
2. *RAAgarwal,R.A., Srivastava,A.K.andKumar,K.2010.AnimalPhysiologyandBiochemistry.Fifthrevisededition.S.Chand Rodwell,V.A., Bender,D.A.,Botham,K.M.,Kennelly,P.J.andWeil,P.A.2018. Harper'sIllustratedBiochemistry,31st edition.McGraw-HillEducation*

BIOCHEM-534 NUTRITIONAL BIOCHEMISTRY 3 (2+1)

Objectives

To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.

Theory

BLOCK1: NUTRITIONALBIOCHEMISTRY

Unit1:Fundamentalsofhumannutrition

Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energyandfoodvalueofvariousfoodgrains(includingcereals,pulses,oilseeds),fruitsandvegetables. Physico-chemical,functionalandnutritionalcharacteristicsofcarbohydrates,proteinsandfatsandtheirinteractions(emulsions,gelation,browningetc.).Digestionand absorption,digestivesecretions,theircharacteristicfeaturesandcontrol,protectionofmicrofloraoftheGItract.

Unit2:Biochemicalfunctionsofnutrients

Biochemicalfunctionsofnutrients,macro-andmicronutrients-carbohydrates,fatsandproteins,vitamins,watersolubleandfatsolublevitamins,mineralandphytonutrients,prebiotics and probiotics, enzymes and metabolic protein factors, cofactor role, electrolyticfunction,constituentsofskeletaltissues,interrelationshipinnutrientfunctions,mineraldeficiencydiseases;nutraceuticals,antinutritionalfactors,biochemistryofpostharveststorage.

Unit3:Bioavailabilityofnutrients

Factors affecting bioavailability of nutrients, biological value of proteins; effect of cooking,processingandpreservationofdifferentfoodproductsonnutrients,energy-andmicronutrientmalnutrition,deficiencydiseasesofmacroandmicronutrients.

Unit4:Foodsensitivity

Foodsensitivity:immunologicallymediatedfoodsensitivity,natureandpropertiesofantigens in foods, mechanism of induction of all allergic reactions, diagnostic tests for food,hypersensitivity,non-immunologicallymediatedfoodsensitivity,foodsensitivityduetometabolicdiseases,gastrointestinaldiseases,foodadditives,pharmacologicagents,foodtoxinsand poisonousand psychologicalfactors.

Lecture Schedule-Theory

S. No.	**Topics**	No. of Lectures
1	**Unit 1: Fundamentals of human nutrition:** Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables. Physicochemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.). Digestion and absorption, digestive secretions, their characteristic features and control, protection of microflora of the GI tract.	8
2	**Unit 2: Biochemical functions of nutrients:** Biochemical functions of nutrients, macro- and micronutrients-carbohydrates, fats and proteins, vitamins, water soluble and fat soluble vitamins, mineral and phytonutrients, prebiotics and probiotics, enzymes and metabolic protein factors, cofactor role, electrolytic function, constituents of skeletal tissues, interrelationship in nutrient functions, mineral deficiency diseases; nutraceuticals, antinutritional factors, biochemistry of postharvest storage.	8
3	**Unit 3: Bioavailability of nutrients:** Factors affecting bioavailability of nutrients, biological value of proteins; effect of cooking, processing and preservation of different food products on nutrients, energy- and micronutrient malnutrition, deficiency diseases of macro and micronutrients.	9
4	**Unit 4: Food sensitivity:** Food sensitivity: immunologically mediated food sensitivity, nature and properties of antigens in foods, mechanism of induction of all allergic reactions, diagnostic tests for food, hypersensitivity, onimmunologically mediated food sensitivity, food sensitivity due to metabolic diseases, gastrointestinal diseases, food additives, pharmacologic agents, food toxins and poisonous and psychological factors.	10
Total		**35**

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Estimation of amylose and amylopectin.	1
2	Estimation of resistant starch.	1
3	Estimation of antioxidants activity.	1
4	Estimation of phenols in plant tissue/sample.	1
5	Estimation of carotenoids.	1
6	Estimation of amylase, trypsin and chymotrypsin inhibitor activities.	2
7	Estimation of Vitamin C in fruits.	2
8	Estimation of reducing & non reducing sugar in fruits.	2
9	Estimation of protein contents.	2
10	Estimation of dietary fibre.	1
11	Determination of limiting amino acids.	2
12	Estimation of phytate/ oxalate.	2
13	Estimation of total antioxidant activity by different methods.	2
14	Estimation of capsaicin.	1
Total		**21**

Suggested Readings

1. *DamodaranS.andParkinKL(ed.)2017.Fennema'sFoodChemistry.CRCPress*
2. *GibneyMJ,Lanham-NewSA,Cassidy,AandVosterHH(ed.)2009.IntroductiontoHumanNutrition.Wiley-Blackwell*
3. *Trueman,P.2007.NutritionalBiochemistry.MJPPublishers*
4. *Cox,C.2015.NutritionalBiochemistry:CurrentTopicsinNutritionResearch.AppleAcademicPressInc.*
5. *Haugen,S.andMeijer,S.2010.HandbookofNutritionalBiochemistry:Genomics,Metabolomics&FoodSupply.NovaSciencePublishersInc.*

BIOCHEM-533 IMMUNO CHEMISTRY 3 (3+0)

Objective

Togiveaninsightintothebiochemicalbasisofimmunity.

Theory

BLOCK1:BASICSOFIMMUNOLOGY

Unit1:Introductiontoimmunology: History and scope of immunology, antigens, adjuvants, immune system, organs, tissues andcells,immunoglobulins,molecularorganizationofimmunoglobulin.haptens,Ag-Abinteraction,plantimmunity,proteasomemediatedprocess,plantibodies.

Unit2:Antibodies:

Classesofantibodies,antibodydiversity,theoriesofgenerationofantibodydiversity,vaccine,monocl

onalandpolyclonalantibodies,hybridoma,recombinantantibodies,complementsystem-classicalandalternate.

Unit3:Theimmuneresponses: Cellular interactions in immuneresponse,major histocompatibilitycomplex, cell mediatedimmune response,cytokines.

Unit4:Immunoregulationandimmunologicaltechniques:

(Immunoregulation,immunologicaltolerance,hypersensitivity,mechanismsofimmunity,innateresistanceandspecificimmunity,currentimmunologicaltechniques–ELISA,RIA,immunoblotting,FACS;basicsofPCRandhybridizationbasedmethodsofdetection,microarraybased detection,multiplexing.

Lecture Schedule-Theory

S. No.	**Topics**	**No. of Lectures**
1	History and scope of immunology, antigens, adjuvants, immune system, organs, tissues andcells,immunoglobulins,molecularorganizationofimmunoglobulin.haptens,Ag-Abinteraction,plantimmunity,proteasomemediatedprocess,plantibodies.	8
2	Classesofantibodies,antibodydiversity,theoriesofgenerationofantibodydiversity,vaccine,monoclonalandpolyclonalantibodies,hybridoma,recombinantantibodies,complementsystem-classicalandalternate.	6
3	Cellular interactions in immuneresponse,major histocompatibilitycomplex, cell mediatedimmune response,cytokines.	10
4	Immunoregulation,immunologicaltolerance,hypersensitivity,mechanismsofimmunity,innateresistanceandspecificimmunity,currentimmunologicaltechniques–ELISA,RIA,immunoblotting,FACS;basicsofPCRandhybridizationbasedmethodsofdetection,microarraybased detection,multiplexing.	10
Total		**34**

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Handling,inoculationandbleedingoflaboratoryanimals.	1
2	Preparationofantigensandantisera,naturalantibodies.	1
3	Carbonclearancetest.	1
4	Lymphoidorgansofthemouse.	1
5	Morphologyofthebloodleucocytes.	1
6	Separationoflymphocytesfromblood,viablelymphocytecount.	2
7	Antigen-antibodyinteraction.	1
8	Precipitationandagglutination.	2
9	Directandindirecthaemagglutination.	1
10	Immunoelectrophoresis.	1
11	Complementfixation.	1
12	Quantitationofimmunoglobulinsbyzincsulphateturbidityandsingleradialimmune diffusion.	1
13	ELISA.	2
14	Westernblotting.	1
15	FluorescentAbtest.	1
16	Hybridomatechnique.	2
	Total	**20**

Suggested Readings

1. *Punt, J., Stranford, S., Jones, P., Owen, J. 2018 . Kuby Immunology. 8th edition. W. H.Freeman*
2. *Renshaw,S.2016.ImmunohistochemistryandImmunocytochemistry:EssentialMethods,2nd Edition.JohnWiley&Sons,Ltd.*
3. *Abbas,A.K.,Lichtma,A.H.andPillai,S.2018.CellularandMolecularImmunology.9th edition.Elsevier*
4. *Delves,P.J.,Martin,S.J.,Burton,D.R.AndRoitt,I.M.2017.Roitt'sEssentialImmunology,13thEdition.Wiley-Blackwell*

BIOCHEM-531BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES 3 (3+0)

Theory

BLOCK 1: BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES

Unit 1: Plant-pathogen interaction and disease development: 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: Role of secondary metabolites, Plant defence response, antimicrobial molecules; genes forresistance, hypersensitive response and cell death; systemic and acquired resistance, pathogenderived resistance

Unit 3: Plant host-virus interaction: Plant viruses, host-virus interactions, disease induction, virus movement, and host rangedetermination; viroids.

Unit 4: Biochemical basis of abiotic stresses: Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavymetals, air and water pollutants, synthesis and functions of proline and glycine betaine instress tolerance interaction between biotic and abiotic stresses; stress adaptation.

Unit 5: Tolerance against stress: Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes of defensesystem. Role of calcium, nitric oxide and salicylic acid in plant development. Molecularstrategies for imparting tolerance against biotic and abiotic stress.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	**Unit 1: Plant-pathogen interaction and disease development:** Molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.	7
2	**Unit 2: Biochemistry of plant defence mechanisms:** Role of secondary metabolites, Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, pathogen derived resistance.	10
3	**Unit 3: Plant host-virus interaction:** Plant viruses, host-virus interactions, disease induction, virus movement, and host rangedetermination; viroids.	7
4	**Unit 4: Biochemical basis of abiotic stresses:** 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.	12
5	**Unit 5: Tolerance against stress:** 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.	12
Total		**48**

Note: BIOCHEM 531 approved for Ph. D. students as minor.

Suggested Readings

1. *Buchanan, Bob B., Gruisem, W. and Jones, R. 2015. Biochemistry and molecular biology of plants, 2nd edition, Wiley Blackwell*
2. *Dresselhaus, T. and Hückelhoven, R. (Eds.) 2019. Biotic and Abiotic Stress Responses in Crop Plants. MDPI. https://doi.org/10.3390/agronomy8110267*
3. *Rout, G. R. and Das, A. B. 2013. Molecular Stress Physiology of Plants. Springer. DOI 10.1007/978-81-322-0807-5*
4. *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*
5. *Ramakrishna, A. and Gill, S. S. 2018. Metabolic Adaptations in Plants During Abiotic Stress. CRC Press*
6. *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*
7. *Smirnoff, N. (ed.) 2005. Antioxidants and reactive oxygen species in plants, Blackwell*

ENTOMOLOGY

Semester Wise Distribution of Courses

S.No.	Course No.	Title of Course	Credit Hrs
M.Sc.(Ag.) Semester-I			
1.	ENT–511	INSECT MORPHOLOGY	3 (2+1)
2.	ENT–512	INSECT ECOLOGY	3 (2+1)
3.	ENT–513	CONCEPTS OF INTEGRATED PEST MANAGEMENT	2 (2+0)
Minor Courses			
4.	PPATH-512	DETECTION AND DIAGNOSIS OF PLANT DISEASES	2 (0+2)
Supporting Courses			
5.	STAT-511	STATISTICAL METHODS FOR APPLIED SCIENCES	3 (2+1)
Common Courses			
6	PGS-511	LIBRARY AND INFORMATION SERVICES	1 (0+1)
Total			14
Semester-II			
1.	ENT–521	INSECT TAXONOMY	3 (2+1)
2.	ENT–522	INSECT ANATOMY AND PHYSIOLOGY	3 (2+1)
3.	ENT–523	TOXICOLOGY OF INSECTICIDES	3 (2+1)
Minor Courses			
4.	PPATH-524/NEMA-521	INTEGRATED DISEASE MANAGEMENT/NEMATODE DISEASES OF CROPS	3(2+1)
5	BIOCHEM-521	BASIC BIOCHEMISTRY	3(2+1)
Total			15
Semester-III			

1.	**ENT–533**	**BIOLOGICAL CONTROL OF INSECT PESTS AND WEEDS**	**3 (2+1)**
Minor Courses			
2.	**PPATH-513/NEMA-531**	**PRINCIPLE OF PLANT PATHOLOGY/ NEMATODE MANAGEMENT**	**3 (2+1)**
Common Courses			
3.	**PGS- 531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5.	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6.	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
	ENT-543	**RESEARCH**	**30**
Semester-IV			
1	**ENT–541**	**SEMINAR**	**1 (0+1)**
2	**ENT-542**	**COMPREHENSIVE**	**NC**
3	**ENT-543**	**RESEARCH**	**30**
NonCore Courses			
1	**ENT-514**	**HOST PLANT RESISTANCE**	**2(1+1)**
2	**ENT-524**	**PEST OF FIELD CROPS**	**3 (2+1)**
3	**ENT–525**	**APICULTURE**	**3 (2+1)**
4	**ENT–526**	**SERICULTURE**	**3 (2+1)**
5	**ENT–527**	**LAC CULTURE**	**3 (2+1)**
6	**ENT–531**	**PESTS OF HORTICULTURAL AND PLANTATION CROPS**	**3 (2+1)**
7	**ENT–532**	**POST HARVEST ENTOMOLOGY**	**2 (1+1)**
8	**ENT–534**	**PRINCIPLE OF ACAROLOGY**	**2 (1+1)**
9.	**ENT–535**	**PLANT QUARANTINE, BIOSAFETY AND BIOSECURITY**	**2 (2+0)**
10.	**ENT–536**	**TECHNIQUES IN PLANT PROTECTION**	**1 (0+1)**
Ph.D.Semester-I			
1.	**ENT–611**	**INSECT PHYLOGENY AND SYSTEMATICS**	**3 (2+1)**
2.	**ENT–612**	**ADVANCED INSECT PHYSIOLOGY AND NUTRITION**	**3 (2+1)**
Minor Courses			

3.	**PPATH-532/NEMA-511**	**DISEASES OF VEGETABLE, FRUITS, AND ORNAMENTAL CROPS/ PRINCIPLE OF NEMATOLOGY**	**3 (2+1)**
Supporting courses			
4.	**PPATH-514**	**DISEASE RESISTANCE IN PLANTS**	**2(2+0)**
Total			**11**
Semester-II			
1.	**ENT–621**	**INSECTICIDE TOXICOLOGY AND RESIDUES**	**3 (2+1)**
2.	**ENT–622**	**BIO-INPUTS FOR PEST MANAGEMENT**	**3 (2+1)**
Minor Courses			
3.	**PPATH-522/PPATH-524/NEMA-521**	**PRINCIPLE OF PLANT DISEASE MANAGEMENT/INTEGRATED DISEASE MANAGEMENT/NEMATODE DISEASES OF CROPS**	**3(2+1)**
Supporting Courses			
4.	**BIOCHEM-522**	**TECHNIQUES IN BIOCHEMISTRY**	**3(1+2)**
III rd and Onward Semester			
1.	**ENT–641**	**DOCTORAL SEMINAR – I**	**1 (0+1)**
2.	**ENT–642**	**DOCTORAL SEMINAR –II**	**1 (0+1)**
3	**ENT–643**	**COMPREHENSIVE**	**NC**
4	**ENT–644**	**RESEARCH**	**75**
Non core courses			
1.	**ENT–613**	**INSECT ECOLOGY AND DIVERSITY**	**3 (2+1)**
2.	**ENT–614**	**MOLECULAR ENTOMOLOGY**	**2 (1+1)**
3.	**ENT–623**	**INTEGRATED PEST MANAGEMENT**	**2 (2+0)**

Non core courses adopted and approved in BoS,out of which one or more courses may be opted in future as and when need arises in future

M.Sc.(Ag.) Programme

ENT 511 INSECTMORPHOLOGY3(2+1)

Objectives

Toacquaintthestudentswiththeexternalmorphologyoftheinsect'sbodyandthefunctioningofvariousbodyparts.

Theory

UNITI

ExternalMorphology:Insectbodywallstructure,cuticularoutgrowths,colourationandspecialintegumentarystructuresininsects, body tagmata,scleritesandsegmentation.

Head-
Origin,**s**tructureandmodification;mouthparts,antennae,theirtypesandfunctioning;tentoriumandnecksclerites.
Thorax-
Areasandsuturesoftergum,sternumandpleuron,pterothorax;wings:structureandmodifications,venation,wingcouplingapparatusandmechanism offlight; legs:structureandmodifications.
Abdomen-Segmentationandappendages;genitaliaandtheirmodifications;embryonicandpost-embryonicdevelopment.

UNITII

Insectsenseorgans(mechano-,photo-andchemo-receptors);organogenensisatpupalstage;insectdefense;chaetotaxy;morphological traits in relationto forensicentomology.

UNITIII

Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of differentimmature stages of crop pests and stored product insects.Comparative study of life history strategies in hemi-metabolaandholometabola,immaturestagesasecologicalandevolutionaryadaptations,significance ofimmaturestagesforpest management. Structure and function of digestive, excretory, circulatory, respiratory, nervous and reproductive system

Lecture ScheduleTheory

S.No.	**Topics**	**No. of Lectures**
1.	ExternalMorphology:Insectbodywallstructure, Cuticularoutgrowths	1
2.	Colourationandspecialintegumentarystructuresininsects	1
3.	Body tagmata,scleritesandsegmentation	1
4.	Head-Origin,**s**tructureandmodification	1
5.	Types of mouthparts	3
6.	Antennae,theirtypesandfunctioning	1
7.	Tentoriumandneckscleri tes	1
8.	Thorax-Areasandsuturesoftergum,sternumandpleuron,pterothorax	1
9.	Wings:structureandmodifications,venation,wingcouplingapparatusandmechanism offlight	3
10.	Legs:structureandmodifications	2
11.	Abdomen-Segmentationandappendages. Genitaliaandtheirmodifications	2
12.	Embryonicandpost-embryonicdevelopment	1
13.	Insectsenseorgans(mechano-,photo-andchemo-receptors);.	2
14.	Insectdefense; chaetotaxy	1
15.	Morphological traits in relationto forensicentomology	1
16.	Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of differentimmature stages of crop	2

	pests and stored product insects.	
17.	Comparative study of life history strategies in hemi-metabolaandholometabola,	1
18.	Immaturestagesasecologicalandevolutionaryadaptations,Significanceofimmaturestagesforpest management	1
19.	Structure and function of digestive, excretory, circulatory, respiratory, nervous and reproductive system	6
Total		**32**

Practical

Preparationofpermanentmountsofdifferentbodypartsandtheirappendagesoftaxonomicimportanceincluding male and female genitalia; dissection of genitalia. Types of immature stages in insects; their collection,rearing and preservation. Identification of immature insects to orders and families, in endopterygote orders viz.,Diptera,Lepidoptera,Hymenopteraand Coleoptera using key.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Studyofinsectsegmentation	1
2.	Studyofvarioustagmataandtheirappendages	1
3.	Preparationofpermanentmountsofdifferentbodypartsandtheirappendagesoftaxonomicimportanceincluding male and female genitalia;	5
4.	Dissection of digestive, excretory and genitalia.	3
5.	Types of immature stages in insects;	1
6.	Insect collection,rearing and preservation.	1
7.	Identification of immature insects to orders and families, in endopterygote orders viz.,Diptera,Lepidoptera,Hymenopteraand Coleoptera using key.	4
Total		**16**

SuggestedReadings

1. *Chapman, RF. 1998. The Insects: Structure and Function. Cambridge Univ. Press, Cambridge.*
2. *Duntson, PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.*
3. *Evans,JW.2004.Outlinesof Agricultural Entomology.AsiaticPubl., NewDelhi.*
4. *Gillott, C.1995.Entomology,2nd Ed.PlenumPress,NewYork,London.*
5. *Gullan, P.J. and Cranston, P.S. 2000. The Insects, An Outline of Entomology, 2nd Ed. Blackwell Science, U.K.*
6. *Richards,OWandDavies,RG.1977.Imm'sGeneralTextBookofEntomology.10th Ed.ChapmanandHall,London.*

7. *Snodgross, RE. 1993. Principles of Insect Morphology. Cornell Univ. Press, Ithaca.*
8 *Tembhore, D.B. 2000. Modern Entomology, Himalaya Publishing House, Mumbai.*
9. *Chu, HF. 1992. How to Know Immature Insects. William Brown Publication, Iowa.*
10. *Peterson,A.1962.Larvaeof Insects. OhioUniversityPress, Ohio.*
11. *Stehr,FW.1998. ImmatureInsects. Vols.I, II.KendallHunt Publication,Iowa.*

ENT 512INSECTECOLOGY3(2+1)

Objectives

To teach the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, constructing life tables, organization of communities, diversity indices. Train students in sampling methodology, calculation of diversity indices, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

UNIT I

History and definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

UNIT II

Basic concepts of abundance- Model vs Real world. Population growth basic models – Exponential vs Logistic models. Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation.

UNIT III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion. Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

UNIT IV

Community ecology- Concept of guild, Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to

pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population; ecological engineering.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Historyanddefinition.BasicConcepts.	1
2	OrganisationoftheBiologicalworld.	1
3	Plato'sNaturalBalancevsEcological Dynamics as the modern view.	1
4	Abundance and diversity of insects, Estimates and Causal factors.	1
5	Study of abundance and distribution and relation between the two.	1
6	Basic principles of abiotic factors and theirgeneralised action on insects.	1
7	Implications for abundance and distribution of organisms including insects- Law oftheMinimum, LawofTolerance, andbiocoenosis, Systemsapproachto ecology.	2
8	Basic concepts of abundance- Model vs Real world.	1
9	Population growth basic models – Exponential vs Logisticmodels.	1
10	Discrete vs Continuous growth models.	1
11	Concepts of Carrying capacity, Environmental Resistance andOptimal yield.	1
12	Vital Statistics- Life Tables and their application to insect biology.	1
13	Survivorship curves.	1
14	Casestudies of insect life tables.	1
15	Population dynamics- Factors affecting abundance- Environmental factors, dispersalandmigration,Seasonalityininsects.	2
16	Classificationandmechanismsofachievingdifferentseasonality-Diapause (Quiescence)- aestivation,hibernation.	1
17	Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology.	1
18	Food chain- webandecologicalsuccession.	1
19	Interspecificinteractions-Basicfactorsgoverningtheinterspecificinteractions-Classification of interspecific interactions - The argument of cost-benefit ratios.	2
20	Competition- Lotka-Volterramodel, Concept of niche ecological homologues, competitive exclusion.	02
21	Evolution of mimicry, colouration,	1
22	Conceptof predatorsatiation;evolutionoflifehistory strategies.	1
23	Community ecology- Concept of guild,	1
24	Relative distribution of organisms,Concept of diversity- the Wallacian view.	1
25	Assessment of diversity.	1

26	Diversity- stability debate, relevance to pestmanagement.	1
27	Pest management as applied ecology.	1
28	Climate change and insect pest/ natural enemy population;ecologicalengineering.	1
Total		**32**

Practical

Types of distributions of organisms. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's Disc equation, Assessment of prey-predator densities from natural systems and understanding the correlation between the two. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Learning outcomes

The students are expected to be well versed with the basic concepts of ecology, ecological succession, population ecology, community ecology, nutritional ecology and different insect-ecosystem interactions.

Quantification of insect diversity and abundance, life table analyses, predator-prey and host-parasitoid relations, functional and numerical responses, niche breadth and overlap.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Typesofdistributionsoforganisms	1
2	Methodsofsamplinginsects	1
3	Estimationofdensitiesofinsectsandunderstandingthedistributionparameters-Measuresofcentraltendencies	2
4	PoissonDistribution,NegativeBinomial Distribution	2
5	Determination of optimal sample size	1
6	Learning to fit basic population growth models andtesting the goodness of fit	2
7	Fitting Holling's Disc equation	1
8	Assessment of prey-predator densities from naturalsystems and understanding the correlation between the two	3
9	Problem solving in ecology	2
10	Field visits to understanddifferentecosystems and tostudyinsectoccurrence inthesesystems	1
Total		**16**

Suggested Readings

1. *Begon, M., Townsend, C.R. and Harper, J. L. 2006. Ecology: From Individuals to Ecosystems. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.*

2. *Chapman J. L. and Reiss MJ. 2006. Ecology: Principles and Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.*
3. *Fowler, J., Cohen, L. and Jarvis, P. 1998. Practical Statistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.*
4. *Gotelli N. J and Ellison AM. 2004. A Primer of Ecological Statistics. Sinauer Associates, Inc., Sunderland, MA.*
5. *Gotelli N. J. 2001. A Primer of Ecology. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA*
6. *Gupta RK. 2004. Advances in Insect Biodiversity. Agrobios, Jodhpur.*
7. *Krebs CJ. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.*
8. *Krebs CJ. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin- Cummings Publ. Co., New York.*
9. *Magurran AE. 1988. Ecological Diversity and its Measurement. Princeton Univ. Press, Princeton.*
10. *Price PW. 1997. Insect Ecology. 3rd Ed. John Wiley, New York.*
11. *Real LA and Brown JH. (Eds). 1991. Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, Chicago.*
12. *Schowalter, Timothy D. 2011. Insect Ecology – An Ecosystem Approach. 3rd Ed. Academic Press, London, UK/ CA, USA.*
13. *Southwood TRE and Henderson PA. 2000. Ecological Methods. 3rd Ed. Methuen and Co. Ltd., London.*
14. *Speight MR, Hunta MD and Watt AD. 2006. Ecology of Insects: Concepts and Application. Elsevier Science Publ., The Netherlands.*
15. *Townsend, Colin R., Begon, Michael and Harper, John L. 2008. Essentials of Ecology. 3rd Ed. Blackwell Publishing, USA/ UK/ Australia.*
16. *Wilson EO and William H Bossert WH. 1971. A Primer of Population Biology. Harvard University, USA.*
17. *Wratten SD and Fry GLA.1980. Field and Laboratory Exercises in Ecology. Arnold, London.*

ENT 513CONCEPTSOFINTEGRATEDPESTMANAGEMENT2(2+0)

Objectives

TofamiliarizethestudentswithprinciplesofinsectpestmanagementincludingconceptandphilosophyofIPM**.** Trainstudents in computation ofETLand implementing IPM programmes.

Theory

UNITI

History,origin,definitionandevolutionofvariousterminologies.Importanceofresistance,principles, classification, components, types and mechanisms of resistance. National and international level crop protectionorganizations;insecticideregulatorybodies;syntheticinsecticide,bio-pesticideandpheromoneregistrationprocedures;labelclaimofpesticides– theprosand cons.

UNITII

Conceptandphilosophy,ecologicalprinciples,economicthresholdconceptandeconomicconsideration.Insect-hostplantrelationships;theories andbasisof host plantselectionin phytophagousinsects.

UNITIII

Toolsofpestmanagementandtheirintegration-legislative,quarantineregulations,cultural,physicalandmechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey andsurveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political,social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partialbudgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organicfarming;components ofecologicalengineering withsuccessful examples.

UNITIV

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimationmethods; crop loss assessment directlosses, indirect losses, potential losses, avoidable losses, unavoidablelosses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing andimplementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation ofwildplantspecies;gene transfer,successfulexamplesof resistantcropvarietiesinIndia andworld.

Learningoutcomes

Studentsareexpectedtohave significant knowledgeofIPMconcepts,estimationoflossesduetoinsectpests,computationofETL, EIL and shouldbeabletakemanagementdecisions.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	History,origin,definitionandevolutionofvariousterminologies.	1
2.	Importanceofresistance,principles,classification, components, types and mechanisms of resistance.	1
3.	National and international level crop protectionorganizations;insecticideregulatorybodies;	1
4.	Syntheticinsecticide,bio-pesticideandpheromoneregistrationprocedures; labelclaimofpesticides– theprosand cons.	1
5.	Conceptandphilosophy,ecologicalprinciples,economicthresholdconceptandeconomicconsideration	1
6.	Insect-hostplantrelationships;theories andbasisof host plantselectionin phytophagousinsects.	2
7.	Toolsofpestmanagementandtheirintegration-Cultural control	1
8.	Physicalandmechanical methods	2
9.	Legislative,quarantineregulations	1
10.	Semiochemicals-pheromonesandallelochemicalsandtheirpotentialinIPM.,	1
11.	Biotechnological and bio-rational approaches in IPM.	2
12.	Pest survey andsurveillance, forecasting, types of surveys including remote	2

	sensing methods, factors affecting surveys;	
13.	Political,social and legal implications of IPM;	1
14.	Pest risk analysis; pesticide risk analysis	1
15.	Cost-benefit ratios and partialbudgeting; case studies of successful IPM programmes.	1
16.	ITK-s in IPM, area-wide IPM and IPM for organicfarming;components ofecologicalengineering withsuccessful examples	1
17.	Characterization of agro-ecosystems;	1
18.	Sampling methods and factors affecting sampling; population estimationmethods;	1
19.	Crop loss assessment directlosses, indirect losses, potential losses, avoidable losses, unavoidablelosses;	2
20.	Global and Indian scenario of crop losses.	1
21.	Computation of EIL and ETL;	1
22.	Crop modeling; designing andimplementing IPM system.	2
23.	Screening techniques;	1
24.	Breeding for insect resistance in crop plants;	1
25.	Exploitation ofwildplantspecies;	1
26.	Gene transfer,successfulexamplesof resistantcropvarietiesinIndia andworld.	1
Total		**32**

SuggestedReadings

1. *DhaliwalGSandAroraR.2003.IntegratedPestManagement–ConceptsandApproaches.KalyaniPubl.,NewDelhi.*
2. *Horowitz AR and Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi.*
3. *IgnacimuthuSSandJayarajS.2007.BiotechnologyandInsectPestManagement.ElitePubl., NewDelhi.*
4. *PedigoRL.2002.Entomology andPestManagement. 4thEd. Prentice Hall,NewDelhi.*
5. *NorrisRF,Caswell-ChenEPandKoganM.2002.ConceptsinIntegratedPestManagement.PrenticeHall,NewDelhi.*
6. *SubramanyamBandHagstrumDW.1995.IntegratedManagementofInsectsinStoredProducts.MarcelDekker, NewYork.*

ENT 521 INSECTTAXONOMY 3(2+1)

Objectives

To sensitize the students on the theory and practice of classifying organisms (with special reference to animals)and the rules governing the same. To introduce the students to the classification of insects up to the level of families with hands on experience inidentifying the families of insects with an emphasis on the practical aspects.

Theory

UNITI

History of insect classification; principles of systematics and its importance. Identification, purpose, methodscharactermatrix,taxonomickeys.Descriptions-subjectsofdescriptions,characters,natureofcharacters,analogy v/s homology, parallel v/s convergent evolution, intraspecific variation in characters, polythetic andpolymorphic taxa, sexual dimorphism. Brief evolutionary history of insects- introduction to phylogeny of insectsand Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- andthe Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses.Process of speciation and interbreeding allopatric species. Molecular systemnatics, DNA barcoding, karyologicalandbiochemicalapproachesintaxonomy.Insectlabelingprotocolsandprocedures.

UNITII

Distinguishing characters, general biology, habits and habitats of insect orders and economically importantfamilies contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha,Thysanura.Subclass:Pterygota,DivisionPalaeoptera– OdonataandEphemeroptera.Division:Neoptera:Subdivision:OrthopteroidandBlattoidOrders(=Oligoneoptera:Plecoptera,Blattodea,Isoptera,Mantodea, Grylloblattodea,Dermaptera,Orthoptera,Phasmatodea,Mantophasmatodea,Embioptera,Zoraptera),Subdivision:HemipteroidOrders(=Paraneoptera):Psocoptera,Phthiraptera,ThysanopteraandHemiptera.

UNITIII

Distinguishing characters, general biology, habits and habitats of insect orders and economically importantfamilies contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid-Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section PanorpoidOrdersMecoptera,Siphonaptera,Diptera,Trichoptera,Lepidoptera,andSectionHymenopteroidOrders:Hymenoptera.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	History of insect classification; principles of systematics and its importance.	1
2.	Identification, purpose, methodscharactermatrix,taxonomickeys.	1
3.	Descriptions-subjectsofdescriptions,characters,natureofcharacters,analogy v/s homology, parallel v/s convergent evolution, intraspecific variation in characters, polythetic andpolymorphic taxa, sexual dimorphism.	2
4.	Brief evolutionary history of insects- introduction to phylogeny of insectsand Classification of Superclass	1
5.	International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses.	1

6.	Process of speciation and interbreeding allopatric species.	1
7.	Molecular systemnatics, DNA barcoding, karyologicalandbiochemicalapproachesintaxonomy.	1
8.	Insectlabelingprotocolsandprocedures	1
9.	Distinguishing characters, general biology, habits and habitats of insect orders and economically importantfamilies contained in them. Order: Collembola, Protura, Diplura.	1
10.	Order: Archaeognatha,Thysanura.	1
11.	Order: OdonataandEphemeroptera.	1
12.	Order: Plecoptera,Blattodea,	1
13.	Order: Mantodea, Grylloblattodea	1
14.	Order: Dermaptera,Phasmatodea,Mantophasmatodea,	1
15.	Order: Orthoptera,	1
16.	Order: Embioptera,Zoraptera	1
17.	Order: Psocoptera, Phthiraptera	1
18.	Order: Thysanoptera	1
19.	Order: Hemiptera	2
20.	Order: Strepsiptera, Megaloptera	1
21.	Order: Raphidioptera, Neuroptera	1
22.	Order: Coleoptera	1
23.	Order: Mecoptera,Siphonaptera	1
24.	Order: Diptera	2
25.	Order: Trichoptera	1
26.	Order: Lepidoptera	2
27.	Order: Hymenoptera	2
Total		**32**

Practical

Study of Orders of insects and their identification using taxonomic keys. Keying out families of insects ofdifferentmajorOrders:Odonata,Orthoptera,Blattodea,Mantodea,Isoptera,Hemiptera,Thysanoptera,Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Field visits to collect insects ofdifferentorders.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Study of Orders of insects and their identification using taxonomic keys.	1
2	Keying out families of insects ofdifferentmajorOrders:Odonata,Orthoptera	1
3	Blattodea,Mantodea	1
4	Isoptera,Hemiptera	2

5	Thysanoptera,Phthiraptera	1
6	Neuroptera, Coleoptera	2
7	Diptera, Hymenoptera	2
8	Lepidoptera	2
9	Field visits to collect insects ofdifferentorders	4
Total		**16**

SuggestedReadings

1. *CSIRO1990.TheInsectsofAustralia:ATextBook forStudentsandResearchers.2nd Ed.Vols.IandII,CSIRO.Cornell Univ. Press,Ithaca.*
2. *FreemanSandHerronJC.1998.Evolutionary Analysis.Prentice Hall,NewDelhi.*
3. *Gullan,P.J.andCranston,P.S.2010.TheInsects:AnoutlineofEntomology.4th Ed.Wiley-BlackwellPublications,West Sussex,UK.*
4. *Mayr,E. 1971.Principles ofSystematicZoology.TataMcGrawHill,NewDelhi.*
5. *RichardsOWandDaviesRG.1977.Imm'sGeneralTextBookofEntomology.10th Ed.Chapma nandHall,London.*
6. *RossHH.1974.BiologicalSystematics. AddisonWesleyPubl.Company.*
7. *TriplehornCAandJohnsonNF.1998.BorrorandDeLong'sIntroductiontotheStudyofInsects .7th Ed.Thomson/Brooks/ Cole, USA/Australia.*

ENT 522INSECT ANATOMYANDPHYSIOLOGY3(2+1)

Objectives

To impart knowledge about the anatomy and physiology of insect body systems ; nutritional physiology; and their applications in entomology.

Theory

UNITI

Scopeandimportanceofinsectphysiology;physiologyofintegument,moulting,chemistryofcuticle, biosysthesisofchitin;growth,hormonalcontrol,metamorphosisanddiapause;pheromonesecretion,t ransmission,perception and reception.

UNITII

Physiologyandmechanismofdigestion,circulation,respiration,excretion,reproduction,secretion(**e xocrine**&endocrine glands)and nerve impulsetransmissionin insects.

UNITIII

Importanceofinsectnutrition-roleofvitamins,proteins,aminoacids,carbohydrates,lipids,mineralsandotherfoodconstituents;extr aandintra-cellularmicroorganisms andtheirroleinphysiology; artificialdiets.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Scopeandimportanceofinsectphysiology	1

2	Physiologyofintegument,chemistryofcuticle, biosysthesisofchitin,	2
3	Moulting process in insect cuticle	1
4	Growth, metamorphosisanddiapause;	2
5	Hormonalcontrol, Pheromonesecretion,transmission,perception and reception	2
6	Physiologyandmechanismofdigestion	2
7	Physiologyandmechanismofcirculation,	2
8	Physiologyandmechanismofrespiration,	2
9	Physiologyandmechanismofexcretion,	2
10	Physiologyandmechanismofreproduction	3
11	Physiologyandmechanismofsecretion(exocrine&endocrine glands)	2
12	Physiologyandmechanismof nerve impulsetransmissionin insects.	2
13	Importanceofinsectnutrition,	1
14	Roleofvitamins,proteins,aminoacids in insect nutrition,	2
15	Role of carbohydrates,lipids,mineralsandotherfoodconstituents	2
16	Extraandintra-cellularmicroorganisms andtheirroleinphysiology	2
17	Artificialdiets for rearing of different insects	2
Total		**32**

Practical

Latest analytical techniques for analysis of free amino acids of haemolymph; determination of chitin in insectcuticle; examination and count of insect haemocytes; preparation and evaluation of various diets; consumption,utilizationand digestion ofnaturalandartificialdiets.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Latest analytical techniques for analysis of free amino acids of haemolymph	3
2	Determination of chitin in insectcuticle	2
3	Examination and count of insect haemocytes	2
4	Gel-electrophoresisfordeterminationofproteinininsecthaemolymph	4
5	Preparationofartificialdietsofdifferentinsects	2
6	Studyoffoodutilizationindices	3
Total		**16**

SuggestedReading

1. *ChapmanRF.1998.Insects:Structureand Function.ELBS Ed.,London.*
2. *DuntsonPA.2004. TheInsects: Structure,FunctionandBiodiversity.KalyaniPubl.,NewDelhi.*
3. *Gullan, P.J. and Cranston, P.S. 2000. The Insects: An Outline of Entomology, 2nd Ed. Blackwell Science, U.K.*

4. *KerkutGAandGilbertLI.1985.ComprehensiveInsectPhysiology,BiochemistryandPharmacology.Vols.I- XIII.PergamonPress,NewYork.*
5. *PatnaikBD.2002. PhysiologyofInsects.DominantPublishers,NewDelhi.*
6. *RichardsOWandDaviesRG.1977.Imm'sGeneralTextBookofEntomology.10thEd.Vol.1.Structure,Physiology and Development.Chapmanand Hall, NewYork.*
7. *Simpson,SJ.2007.AdvancesinInsect Physiology,Vol.33,Academic Press(Elsevier),London,UK.*
8. *WigglesworthVB.1984.InsectPhysiology.8th Ed. Chapmanand Hall, New York.*

ENT 523TOXICOLOGY OFINSECTISIDES 3(2+1)

Objectives

To orient the students with structure and mode of action of important insecticides belonging to different groups,development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

UNITI

Definitionandscopeofinsecticidetoxicology;historyofchemicalcontrol;pesticideuseandpesticideindustryinIndia.

UNITII

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature;categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects ingeneral; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiaryamines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, newpromisingcompounds/newinsecticidemolecules;
nanopesticides;drawbacksofinsecticideabuse.

UNITIII

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides-synergism, potentiationand antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity.bioassaydefinition, objectives, criteria,factors, problems and solutions.

UNITIV

Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticideresistance managementandpest resurgence.

UNITV

Insecticideresidues,theirsignificanceandenvironmentalimplications;proceduresofinsecticideresidueanalysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use ofinsecticides;diagnosisandtreatment of insecticidepoisoning.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures

1.	Definitionandscopeofinsecticidetoxicology	1
2.	Historyofchemicalcontrol	1
3.	PesticideuseandpesticideindustryinIndia	1
4.	Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature;	1
5.	Categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects ingeneral;	1
6.	Structure and mode of action of organochlorines,	1
7.	Structure and mode of action of organophosphates,	1
8.	Structure and mode of action of carbamates,	1
9.	Structure and mode of action of pyrethroids, tertiaryamines	1
10.	Structure and mode of action of neonicotinoids, oxadiazines, phenyl pyrozoles,	2
11.	Structure and mode of action of insect growth regulators, microbials,	2
12.	Structure and mode of action of botanicals, newpromisingcompounds/newinsecticidemolecules;	2
13.	Structure and mode of action of nanopesticides;drawbacksofinsecticideabuse	1
14.	Principles of toxicology	1
15.	Evaluation of insecticide toxicity	1
16.	Joint action of insecticides- synergism, potentiationand antagonism	1
17.	Factors affecting toxicity of insecticides	1
18.	Insecticide compatibility, selectivity and phytotoxicity	1
19.	Bioassaydefinition, objectives, criteria,factors, problems and solutions	1
20.	Insecticide metabolism	1
21.	Insect-pest resistance to insecticides	1
22.	Mechanisms and types of resistance	2
23.	Insecticideresistance managementandpest resurgence	1
24.	Insecticideresidues,theirsignificanceandenvironmentalimplications;procedure sofinsecticideresidueanalysis	2
25.	Insecticide Act	1
26.	Registration procedures, label claim, and quality control of insecticides	1
27.	Safe use ofinsecticides;diagnosisandtreatment of insecticidepoisoning	1
Total		**32**

Practical

Insecticide formulations and mixtures; laboratory and field evaluation of bio-efficacy of insecticides; bioassaytechniques; probit analysis; evaluation of insecticide toxicity. Toxicity to beneficial insects. Pesticide appliances.Workingout dosesandconcentrationsofpesticides. Proceduresofresidueanalysis.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Insecticide formulations and mixtures	1

2.	Laboratory and field evaluation of bio-efficacy of insecticides	2
3.	Bioassaytechniques	2
4.	Probit analysis	2
5.	Evaluation of insecticide toxicity	2
6.	Toxicity to beneficial insects	1
7.	Pesticide appliances	2
8.	Workingout dosesandconcentrationsofpesticides	3
9.	Proceduresofresidueanalysis	1
Total		**16**

SuggestedReadings

1. *Chattopadhyay SB. 1985. Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.*
2. *Gupta HCL.1999.Insecticides: ToxicologyandUses. AgrotechPubl., Udaipur.*
3. *Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.*
4. *MatsumuraF. 1985. ToxicologyofInsecticides.Plenum Press, NewYork.*
5. *PerryAS,YamamotoI,IshaayaIandPerryR.1998.InsecticidesinAgricultureandEnvironment.NarosaPubl.House, NewDelhi.*
6. *PrakashAandRaoJ.1997. BotanicalPesticidesinAgriculture.LewisPublication,NewYork.*
7. *Pedigo,L.P.andMarlin,E.R.2009.EntomologyandPestManagement,6thEdition,PearsonEducationInc.,UpperSaddleRiver, NewJersey07458, U.S.A.*
8. *Dovener,R.A.Mueninghoff,J.C.andVolgar,G.C.2002.Pesticidesformulationanddeliverysystems:meetingthechallenges ofthecurrentcropprotectionindustry.ASTM, USA*
9. *Dodia,D.A.Petel,I.S.andPetal,G.M.2008.BotanicalPesticidesforPestManagement.ScientificPublisher(India), Jodhpur.*
10. *Ishaaya, I. and Degheele, D. 1998. Insecticides with Novel Modes of Action: Mechanism and Application. NorosaPublishingHouse, NewDelhi.*
11. *MathewsG.A.2002. Pesticide ApplicationMethods.4thEd.Intercept.UK.*
12. *Otto, D. and Weber, B. 1991. Insecticides: Mechanism of Action and Resistance. Intercept Ltd., U.K.*
13. *Roy,N.K. 2006.ChemistryofPesticides.AsiaPrintographShahdaraDelhi.*
14. *Krieger,R.I.2001.HandbookofPesticide Toxicology.Vol-II.AcademicPress.OrlandoFlorida.*

ENT 533BIOLOGICALCONTROLOFISECTPESTSANDWEEDS3(2+1)

Objectives

To train the studentswith theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids ,predators and various entomopathogenic microorganisms.

Theory

UNITI

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens;principlesofclassicalbiologicalcontrol-importation,augmentationandconservation.Historyofinsectpathology,infectionofinsectsbybacteria,fungi,viruses,protozoa,rickettsiae,spiroplasma andnematodes.

UNITII

Biology,adaptation,hostseekingbehaviourofpredatoryandparasiticgroupsofinsects.Roleofinsectpathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weedsusing insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factorscontrollingthese.Defensemechanisms in insects againstpathogens.

UNITIII

Mass production of quality bio-control agents- techniques, formulations, economics, field release/application andevaluation.Developmentofinsectaries,theirmaintenance.

UNITIV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importationof natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biologicalcontrol.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1.	History, principles and scope of biological control	3
2.	Important groups of parasitoids, predators and pathogens	3
3.	Principlesofclassicalbiologicalcontrol-importation,augmentationandconservation	2
4.	Historyofinsectpathology,infectionofinsectsbybacteria,fungi,viruses,protozoa, rickettsiae,spiroplasma andnematodes	2
5.	Biology,adaptation,hostseekingbehaviourofpredatoryandparasiticgroupsofinsects	3
6.	Roleofinsectpathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action	6
7.	Biological control of weedsusing insects	1
8.	Epizootiology, symptomatology and etiology of diseases caused by the above and the factorscontrollingthese	2
9.	Defensemechanisms in insects againstpathogens	1
10.	Mass production of quality bio-control agents- techniques, formulations, economics, field release/application andevaluation	3
11.	Developmentofinsectaries,theirmaintenance	1
12.	Successful biological control projects, analysis, trends and future possibilities of biological control	2
13.	Importationof natural enemies- Quarantine regulations	1
14.	Biotechnology in biological control	1

15.	Semiochemicals in biologicalcontrol	1
Total		**32**

Practical

Identificationofcommonnaturalenemiesofcroppests(parasitoids,predators,microbes)andweedkill ers.Visitsto bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupalparasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds.Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insectpathogens.Qualitycontrol and registrationstandardsforbiocontrol agents.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1.	Identificationofcommonnaturalenemiesofcroppests(parasitoids,predators,microbes)andweedkillers.	4
2.	Visitsto bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupalparasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds.	2
3.	Field collection of parasitoids and predators.	4
4.	Hands-on training in culturing, identification of common insectpathogens.	4
5.	Qualitycontrol and registrationstandardsforbiocontrol agents.	2
Total		**16**

SuggestedReadings

1. *BurgesHDandHusseyNW.(Eds).1971.MicrobialControlofInsects andMites. AcademicPress,London.*
2. *DeBachP. 1964.BiologicalControlofInsectPestsandWeeds.ChapmanandHall, NewYork.*
3. *DhaliwalGSandAroraR.2001.IntegratedPestManagement:ConceptsandApproaches.Kal yaniPubl.,NewDelhi.*
4. *GersonHandSmileyRL.1990.AcarineBiocontrolAgents– AnIllustratedKeyandManual.ChapmanandHall,NewYork.*
5. *Huffaker CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London.*
6. *IgnacimuthuSSandJayarajS.2003.Biological ControlofInsectPests.PhoenixPubl.,NewDelhi.*
7. *SaxenaAB.2003.BiologicalControlofInsectPests.Anmol Publ.,NewDelhi.*
8. *VanDriesche andBellowsTS.Jr.1996.BiologicalControl.ChapmanandHall,NewYork.*

Ph.D. Programme

ENT 611INSECT PHYLOGENY AND SYSTEMATICS3(2+1)

Objectives

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

UNIT I

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.

UNIT II

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.

UNIT III

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.

UNIT IV

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 sytematics.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed.	3
2	Development of phenograms, cladograms, molecular approaches for the classification of organisms.	2
3	Methods in identification of homology.	2
4	Species concepts, speciation processes and evidences. Zoogeography.	2
5	Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen.	3
6	Fossil insects and evolution of insect diversity over geological times.	2
7	Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics.	3
8	Nomenclature and documentation protocols and procedures;	2

9	Report preparation on new species;	2
10	Deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.	3
11	Concept of Phylocode and alternative naming systems for animals.	2
12	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.	3
13	Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular sytematics.	3
Total		**32**

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. Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.

Lecture Schedule-Practical

S.No.	Topics	No.of Lectures
1	Collection, curation and study of one taxon of insects- literature search, compilation of a checklist,	2
2	Study of characters, development of character table, and construction of taxonomic keys for the selected group.	3
3	Development of descriptions, photographing, writing diagrams, and preparation of specimens for "type like" preservation.	3
4	Submission of the collections made of the group.	2
5	Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms.	3
6	Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.	3
Total		**16**

Suggested Readings

1. *CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2 nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.*
2. *Dakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer- Verlag, Berlin.*
3. *Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.*

4. *Hennig W. 1960. Phylogenetic Systematics. Urbana Univ. Illinois Press, USA.*
5. *Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2 nd Ed. Academic Press, New York.*
6. *Mayr E and Ashlock PD. 1991. Principles of Systematic Zoology. 2 nd Ed. McGraw Hill, New York.*
7. *Mayr E.1969. Principles of Systematic Zoology. McGraw-Hill, New York.*
8. *Quicke DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional, London.*
9. *Ross HH. 1974. Biological Systematics. Addison Wesley Publ. Co., London.*
10. *Wiley EO. 1981. Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists. Columbia Univ. Press, USA.*

ENT 612 ADVANCED INSECT PHYIOLOGY AND NUTRITION3(2+1)

Objectives

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

UNIT I

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

UNIT II

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.

UNIT III

Detailed physiology of nervous system, transmission of nerve impulses, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

UNIT IV

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.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Physiology and biochemistry of insect cuticle and moulting process.	3
2	Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticlde.	3
3	Digestive enzymes, digestive physiology in phytophagous	2

4	Wood boring and wool feeding insects, efficiency of digestion and absorption	2
5	Role of endosymbionts in insect nutrition, nutritional effects on growth and development;	3
6	Physiology of excretion and osmoregulation, water conservation mechanisms.	3
7	Physiology of nervous system	2
8	Transmission of nerve impulses	2
9	Pheromones and other semiochemicals in insect life, toxins and defense mechanisms.	2
10	Endocrine system and insect hormones	2
11	Physiology of insect growth and development- metamorphosis, polymorphism and diapause.	2
12	Insect behaviour in IPM	2
13	Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management	2
14	Use of semio-chemicals, auditory stimuli and visual signals in pest management.	2
Total		**32**

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: practicing analytical techniques for analysis of free amino acids of haemolymph; zymogram analyses of amylase; determination of chitin in insect cuticle; examination and count of insect haemocytes.

Lecture Schedule-Practical

S.No.	Topics	No.of Lectures
1	Preparation of synthetic diets for different groups of insects;	2
2	Rearing of insects on synthetic, semi-synthetic and natural diets;	2
3	Determination of co-efficient of utilization;	2
4	Qualitative and quantitative profile of bio-molecules	2
5	Practicing analytical techniques for analysis of free amino acids of haemolymph;	3
6	Zymogram analyses of amylase;	2
7	Determination of chitin in insect cuticle; examination and count of insect haemocytes.	3
Total		**16**

Suggested Readings

1. *Ananthkrishnan TN. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.*

2. *Bernays EA and Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, London.*
3. *Kerkut GA and Gilbert LI. 1985. Insect Physiology, Biochemistry and Pharmacology. Vols. I-XIII. Pergamon Press, Oxford, New York.*
4. *Muraleedharan K. 1997. Recent Advances in Insect Endocrinology. Association for Advancement of Entomology, Trivandrum, Kerala. Rockstein, M. 1978. Biochemistry of Insects, Academic Press.*
5. *Simpson, SJ. 2007. Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.*

ENT 621 INSECTISIDE TOXICOLOGY AND RESIDUES3(2+1)

Objectives

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

UNIT I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.

UNIT II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

UNIT III

Joint action of insecticides; activation, synergism and potentiation.

UNIT IV

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 V

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

Lecture Schedule - Theory

S.No.	Topics	No. of Lectures
1	Penetration and distribution of insecticides in insect systems; insecticide selectivity;	2
2	Factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules;	2
3	Developments in bio-rational approaches;	2

4	SPLAT; RNAi technology for pest management.	2
5	Biochemical and physiological target sites of insecticides in insects;	2
6	Developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships;	2
7	Advances in metabolism of insecticides.	2
8	Joint action of insecticides; activation, synergism and potentiation.	2
9	Problems associated with pesticide use in agriculture:	2
10	Pesticide resistance; resistance mechanisms and resistant management strategies;	2
11	Pest resurgence and outbreaks; persistence and pollution;	2
12	Health hazards and other side effects.	2
13	Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods;	2
14	Maximum residue limits (MRLs) and their fixation;	2
15	Bound and conjugated residues, effect on soil fertility	2
16	Insecticide laws and standards, and good agricultural practices.	2
Total		**32**

Practical

Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects; preparation of EC formulation using neem oil;

Lecture Schedule-Practical

S.No.	Topics	No.of Lectures
1	Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods;	4
2	Calculations and interpretation of data;	3
3	Biochemical techniques for detection of insecticide resistance in insects;	3
4	Biological techniques for detection of insecticide resistance in insects;	3
5	Preparation of EC formulation using neem oil;	3
Total		**16**

Suggested Readings

1. *Busvine JR. 1971. A Critical Review on the Techniques for Testing Insecticides. CABI, London.*
2. *Dhaliwal GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publ., New Delhi. Hayes WJ and Laws ER. 1991. Handbook of Pesticide Toxicology. Academic Press, New York.*
3. *Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.*

4. *Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.*
5. *O' Brien RD. 1974. Insecticides Action and Metabolism. Academic Press, New York.*
6. *Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.*
7. *Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publ., New York.*

ENT 622BIO-INPUTS FOR PEST MANAGEMENT3(2+1)

Objectives

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

UNIT I

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-à-vis target pest populations.

UNIT II

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.

UNIT III

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.

UNIT IV

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.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies;	4
2	Nutrition of entomophagous insects and their hosts, dynamics of bio-agents vis-à-vis target pest populations.	4
3	Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio-agents,	4
4	Insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.	4
5	Colonization, techniques of release of natural enemies, recovery evaluation,	2

6	Conservation and augmentation of natural enemies, survivorship analysis	2
7	Ecological manipulations, large-scale production of bio-control agents, bankable project preparation.	4
8	Scope of genetically engineered microbes and parasitoids in biological control,	4
9	Genetics of ideal traits in bio- control agents for introgressing and for progeny selections, breeding techniques of bio-control agents.	4
Total		**32**

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.

Lecture Schedule-Practical

S.No.	Topics	No.of Lectures
1	Mass rearing and release of some commonly occurring indigenous natural enemies;	3
2	Assessment of role of natural enemies in reducing pest populations;	2
3	Testing side effects of pesticides on natural enemies;	2
4	Effect of semio- chemicals on natural enemies, breeding of various bio-control agents,	3
5	Performance of efficiency analyses on target pests;	2
6	Project document preparation for establishing a viable mass-production unit /insectary;	2
7	Observation of feeding behavior acts of predatory bugs/ beetles.	2
Total		**16**

Suggested Readings

1. *Burges HD and Hussey NW. (Eds.). 1971. Microbial Control of Insects and Mites. Academic Press, London.*
2. *Coppel HC and James WM. 1977. Biological Insect Pest Suppression. Springer Verlag, Berlin.*
3. *De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman and Hall, London.*
4. *Dhaliwal, GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publ., New Delhi.*
5. *Gerson H and Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and*

Manual. Chapman and Hall, New York.

6. *Huffakar CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London*

GENETICS AND PLANT BREEDING

Semester Wise Distribution of Courses

S.No.	Course No.	Title	Credit Hrs.
M. Sc. Ag. **Semester- I**			
1	**GPB 511***	**PRINCIPLES OF GENETICS**	**3 (2+1)**
2	**GPB 512***	**PRINCIPLES OF PLANT BREEDING**	**3 (2+1)**
3	**GPB 513/ GPB 514**	**SEED PRODUCTION & CERTIFICATION/ VARIETAL DEVELOPMENT AND MAINTENANCE BREEDING**	**2 (1+1)**
Minor Courses			
4	**PPHYS-513/PPATH-512**	**PHYSIOLOGY OF FIELD CROPS/TECHNIQUES IN DETECTION AND DIAGNOSIS OF PLANT DISEASES**	**2(2+0) /2(0+2)**
Supporting Courses			
5	**STAT-511**	**STATITICAL METHOD FOR APPLIED SCIENCES**	**3(2+1)**
Common Courses			
6	**PGS-511**	**LIBRARY AND INFORMATION SERVICES**	**1(0+1)**
Total			**14**
Semester- II			
1	**GPB 521**	**PRINCIPLES OF CYTOGENETICS**	**3 (2+1)**
2	**GPB 522***	**FUNDAMENTALS OF QUANTITATIVE GENETICS**	**3 (2+1)**
3	**GPB 523/ GPB 524/ GPB 525**	**MUTAGENESIS & MUTATION BREEDING/ HYBRID BREEDING/ BREEDING FOR STRESS RESISTANCE AND CLIMATE CHANGE**	**3 (2+1)**
MinorCourses			
4.	**PPHYS-522/PPHYS-523/PPATH-524**	**PLANT DEVELOPMENT BIOLOGY: PHYSIOLOGICAL AND MOLECULAR BASIS/SEED PHYSIOLOGY/INTEGRTED DISEASE MANAGEMENT**	**3 (2+1)**
Supporting Courses			

5.	**STAT-521**	**EXPERIMENTAL DESIGN**	**3 (2+1)**
Total			**15**
Semester- III			
1	**GPB 531***	**MOLECULAR BREEDING AND BIOINFORMATICS**	**3 (2+1)**
Minor Course			
2	**VSC-531, BIOCHEM-511**	**SEED PRODUCTION OF VEGETABLE CROPS/PLANT BIOCHEMISTRY**	**3(2+1)**
Common Courses			
3.	**PGS -531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4.	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5.	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6.	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
7.	**GPB 543****	**RESEARCH**	**30**
Semester- IV			
1	**GPB 541**	**SEMINAR**	**1(0+1)**
2	**GPB 542**	**COMPREHENSIVE**	**NC**
3	**GPB543**	**RESEARCH**	**30 Continue**
Non Core Courses			
1	**GPB 526**	**GERMPLASM CHARACTERIZATION AND EVALUATION**	**2 (1+1)**
2	**GPB 527**	**CROP BREEDING II RABI CROPS**	**3 (2+1)**
3	**GPB 528**	**BREEDING VEGETABLE CROPS**	**3 (2+1)**
4	**GPB 532**	**CROP BREEDING I KHARIF CROPS**	**3 (2+1)**
5	**GPB 533**	**BREEDING FOR QUALITY AND SPECIAL TRAITS**	**3 (2+1)**
6	**GPB 534**	**GENETIC ENHANCEMENT FOR PGR UTILIZATION**	**2 (1+1)**
7	**GPB 535**	**BREEDING FRUIT CROPS**	**3(2+1)**
Ph. D.			
Semester- I			
1	**GPB 611***	**ADVANCES IN PLANT BREEDING SYSTEMS**	**3 (3+0)**
2	**GPB 612***	**IPR AND REGULATORY MECHANISM (e-COURSE)**	**1 (1+0)**

3	**GPB 613/ GPB 614**	**PLANT GENETIC RESOURCES, CONSERVATION AND UTILIZATION/ MOLECULAR CYTOGENETICS FOR CROP IMPROVEMENT**	**2 (2+0)**
Minor Courses			
4	**PPATH-513/PPHYS-531/BIOCHEM-531**	**PRINCIPLES OF PLANT PATHOLOGY/HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT/BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES**	**3(2+1)/ 3 (3+0)**
Supporting courses			
5	**PPATH-514**	**DISEASE RESISTANCE IN PLANTS**	**2 (2+0)**
Total			**11**
Semester- II			
1	**GPB 621***	**GENOMICS IN PLANT BREEDING**	**3 (3+0)**
2	**GPB 622/ GPB 623**	**ADVANCES IN BIOMETRICAL GENETICS/CROP EVOLUTION**	**3 (2+1)/ 3(3+0)**
Minor Courses			
3	**PPATH-522/VSC-523**	**PRINCIPLES OF PLANT DISEASE MANAGEMENT/BREEDING OF CROSS POLLINATED VEGETABLE CROPS**	**3 (2+1)**
Supporting Courses			
4	**BIOCHEM-522**	**TECHNIQUES IN BIOCHEMISTRY**	**3(1+2)**
IIIrd and onward Semester			
1	**GPB 641**	**DOCTORAL SEMINAR I**	**1 (1+0)**
2	**GPB 642**	**DOCTORAL SEMINAR II**	**1 (1+0)**
3	**GPB 643**	**COMPREHENSIVE**	**NC**
4	**GPB 644**	**DOCTORAL RESEARCH**	**75**
Non Core Courses			
4	**GPB 624**	**POPULATION GENETICS**	**2 (2+0)**
5	**GPB 625**	**BREEDING DESIGNER CROPS**	**2(1+1)**

Non core courses adopted and approved in BoS,out of which one or more courses may be opted in future as and when need arises in future

*** Compulsory major courses; ** will be continued**

Note: The total credit hours of research work will be distributed in different semesters as per progress of the work under the guidance of major advisor.

M.Sc.(Ag.) Programme

GPB 511 PRINCIPLES OF GENETICS 3 (2+1)

Objectives

This course is aimed at understanding the basic concepts of inheritance of genetictraits, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics

Theory

Beginning of genetics**,** early concepts of inheritance, Mendel's laws; Discussion onMendel'spaper,Chromosomaltheoryofinheritance;Multiplealleles,Geneinteractions,Sexdetermination,differentiationandsex-linkage,sex-influencedandsex-limited traits; Linkage-detection, estimation; Recombination and genetic mappingineukaryotes,Somaticcellgenetics,Extrachromosomalinheritance.Mendelianpopulation,Randommatingpopulation,Frequenciesofgenesandgenotypes,Causes ofchange: Hardy-Weinbergequilibrium.Nature,structureandreplicationofthegeneticmaterial;OrganizationofDNAinchromosomes,Geneticcode;Proteinbiosynthesis,Geneticfinestructureanalysis,Alleliccomplementation,Splitgenes,Overlappinggenes,Pseudogenes,Oncogenes,Genefamiliesandclusters;Regulationofgeneactivityinprokaryotesandeukaryotes;Molecularmechanismsofmutation,repairandsuppression;Bacterialplasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones andgeneexpression, RNAediting.Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs). Genome-editing Technologies, Principles and Applications: Clustered regularly interspaced short palindromic repeats (CRISPR)-CRISPR-associated protein 9 (Cas9), transcription activator-like effector nucleases (TALENs), zinc-finger nucleases (ZFNs) and homing endonucleases or meganucleases.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Beginning of genetics**,** early concepts of inheritance	1
2.	Mendel's laws, Discussion on Mendel's paper	1
3.	Chromosomal theory of inheritance & Multiple alleles	1
4.	Gene interactions	1
5.	Sex determination & differentiation	1
6.	Sex-linkage, sex-influenced and sex-limited traits	1
7.	Linkage-detection, estimation	1

8.	Recombination and genetic mapping in eukaryotes	1
9.	Somatic cell genetics	1
10.	Extra chromosomal inheritance	1
11.	Mendelian population, Random mating population	1
12.	Frequencies of genes and genotypes, Causes of change	1
13.	Hardy-Weinberg equilibrium	1
14.	Nature, structure and replication of the genetic material	1
15.	Organization of DNA in chromosomes	1
16.	Genetic code	1
17.	Protein biosynthesis	1
18.	Genetic fine structure analysis, Allelic complementation	1
19.	Split genes, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters	1
20.	Regulation of gene activity in prokaryotes and eukaryotes	1
21.	Molecular mechanisms of mutation, repair and suppression	1
22.	Bacterial plasmids, insertion (IS) and transposable (Tn) elements	1
23.	Molecular chaperones and gene expression, RNA editing	1
24.	Gene isolation, synthesis and cloning	1
25.	Genomic and cDNA libraries	1
26.	PCR based cloning, positional cloning	1
27.	Nucleic acid hybridization and immunochemical detection	1
28.	DNA sequencing	1
29.	DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).	1
30.	Genome-editing Technologies, Principles and Applications	1
31.	Clustered regularly interspaced short palindromic repeats (CRISPR)-CRISPR-associated protein 9 (Cas9)	1
32.	Transcription activator-like effector nucleases (TALENs), zinc-finger nucleases (ZFNs), and homing endonucleases or meganucleases	1
Total		**32**

Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms;Numerical exercises based on gene interactions; Chromosome mapping using three-point test cross;Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction; PCR amplification; Electrophoresis: basic principles and running of amplified DNA; Extraction of proteins and isozymes;

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Laboratory exercises in probability	1
2.	Laboratory exercises in chi-square	1
3.	Demonstration of genetic principles using laboratory organisms	2
4.	Numerical exercises based on gene interactions	2
5.	Chromosome mapping using three-point test cross	2
6.	Tetrad analysis	1
7.	Induction and detection of mutations through genetic tests;	1
8.	DNA extraction	2
9.	PCR amplification	1
10.	Electrophoresis: basic principles and running of amplified DNA	2
11.	Extraction of proteins and isozymes	1
Total		**16**

Suggested Readings

1. *DanielLHandMaryellenR.2011.Genetics:"AnalysisofGenesandGenomes".*
2. *GardnerEJandSnustadDP.1991.PrinciplesofGenetics.JohnWileyandSons.8thed.2006KlugWSandCummingsMR.2003.ConceptsofGenetics.PetersonEdu.PearsonEducation*
3. *India;Tenthedition*
4. *Lewin B. 2008. Genes XII. Jones and Bartlett Publ. (International Edition) Paperback, 2018RussellPJ.1998.Genetics.TheBenzamin/CummingsPubl.Co*
5. *SinghBD. 2009. Genetics.Kalyani Publishers (2ndRevised Edition)*
6. *SnustadDPandSimmonsMJ.2006.Genetics.4thEd.JohnWileyandSons.6thEditionInternationalStudentVersionedition*
7. *StansfieldWD.1991.Genetics.SchaumOutlineSeriesMcGrawHill*
8. *StrickbergerMW.2005.Genetics(IIIEd).PrenticeHall,NewDelhi,India;3rded.,2015TamarinRH.1999.PrinciplesofGenetics.Wm.C.BrownPubls.,McGrawHillEducation;7edition*

9. *UppalS,YadavR,SinghSandSaharanRP.2005.PracticalManualonBasicandAppliedGenetics.Dept.ofGenetics,CCSHAUHisar.*
10. *Russell PJ.2018. I Genetics a Molecular Approach. Indian edition published by Pearson Indian Education Services Pvt. Ltd.*

GPB 512 PRINCIPLES OF PLANT BREEDING 3 (2+1)

Objectives

To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement

Theory

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plantbreeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversityand its significance. Pre-breeding and plant introduction and role of plant geneticresourcesinplantbreeding.Geneticbasisofbreeding:selfandcrosspollinatedcropsincludingmatingsystemsand response to selection; Nature of variability, components of variation; Heritabilityandgeneticadvance,genotypeenvironmentinteraction;Generalandspecificcombiningability;Typesofgeneactionsandimplicationsinplantbreeding.Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross,single seed descent and multiline breeding; Population breeding in self-pollinatedcropswithspecialreferencetodiallelselectivemating;Transgressivebreeding.Breeding methods in cross pollinated crops; Population breeding: mass selectionand ear-to-row methods; S_1 and S_2 progeny testing, progeny selection schemes,recurrentselectionschemesforintraandinter-populationimprovementanddevelopmentofsyntheticsandcomposites.

Geneticandphysiological basis of heterosis and inbreeding, production of inbreeds, breedingapproachesforimprovementofinbreeds,predictinghybridperformance;seedproduction of hybrid and their parent varieties/inbreeds. Self-incompatibility, malesterilityandapomixesincropplantsandtheircommercialexploitation.Breedingmethodsinasexually/clonallypropagatedcrops,clonalselection.Specialbreedingtechniques:Mutationbreeding,Breedingforabioticandbioticstresses;Conceptofplantideotypeanditsroleincropimprovement,conceptofMAS,concept ofpolyploidy andwide hybridization,doubled haploidy.Cultivardevelopment:testing,releaseandnotification,maintenancebreeding,Participatory Plant Breeding, Plant breeders' rights and regulations for plant varietyprotectionandfarmersrights.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Early plant breeding; accomplishments through plant breeding	1
2.	Objectives of plantbreeding & patterns of evolution in crop plants	1
3.	Centre of Origin, Agro-biodiversityand its significance	1

4.	Pre-breeding and plant introduction and role of plant geneticresourcesinplantbreeding.	1
5.	Genetic basis of breeding: self and cross pollinated crops including mating systems and response to selection	1
6.	Nature of variability, components of variation; Heritabilityandgeneticadvance	1
7.	Genotypeenvironmentinteraction	1
8.	General and specific combining ability	1
9.	Types of gene actions and implications in plant breeding.	1
10.	Pure line theory, pure line and mass selection methods	1
11.	Pure line and mass selection methods	1
12.	Pedigree, bulk, single seed descent	1
13.	Backcross	1
14.	Multiline breeding	1
15.	Population breeding in self-pollinated crops with special reference to diallel selective mating, transgressive breeding	1
16.	Breeding methods in cross pollinated crops, Population breeding	1
17.	Mass selection and ear-to-row methods	1
18.	S_1 and S_2 progeny testing, progeny selection schemes	1
19.	Recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites	2
20.	Genetic and physiological basis of heterosis and inbreeding	1
21.	Production of inbreds, breeding approaches for improvement of inbreds	1
22.	Predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds	1
23.	Self-incompatibility, male sterility and their commercial exploitation	1
24.	Apomixes in crop plants and their commercial exploitation	1
25.	Breeding methods in asexually/clonally propagated crops, clonal selection	1
26.	Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses	1
27.	Concept of plant ideotype and its role in crop improvement	1
28.	Concept of MAS	1

29.	Concept of polyploidy and wide hybridization, doubled haploidy	1
30.	Cultivar development: testing, release and notification	1
31.	Maintenance breeding, Participatory Plant Breeding,	1
32.	Plant breeders' rights and regulations for plant variety protection and farmers rights	1
Total		**32**

Practical

Floralbiologyinselfandcrosspollinatedspecies;Selfingandcrossingtechniques;Selectionmethodsinsegregatingpopulationsandevaluationofbreedingmaterial;Analysisofvariance(ANOVA);Estimationofheritabilityandgeneticadvance;Maintenanceofexperimentalrecords;Learningtechniques in hybridseed production usingmale-sterility in fieldcrops; Predictionofperformanceofdoublecrosshybrid.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Floralbiologyinself pollinatedspecies	2
2.	Floralbiologyincrosspollinatedspecies	2
3.	Selfingandcrossingtechniques	2
4.	Selectionmethodsinsegregatingpopulations	2
5.	Evaluationofbreedingmaterial	1
6.	Analysisofvariance(ANOVA)	2
7.	Estimationofheritabilityandgeneticadvance	1
8.	Maintenanceofexperimentalrecords	1
9.	Learningtechniques in hybridseed production usingmale-sterility in fieldcrops	2
10.	Predictionofperformanceofdoublecrosshybrid	1
Total		**16**

Suggested Readings

1. *AllardRW.1981. PrinciplesofPlantBreeding (second edition).JohnWiley&Sons.*
2. *ChahalGSandGossal,SS.2002.PrinciplesandProceduresofPlantBreedingBiotechnologicalandConventionalapproaches.NarosaPublishingHouse.*
3. *ChopraVL.2004.PlantBreeding.Oxford&IBH.*
4. *GeorgeA.2012.PrinciplesofPlantGeneticsandBreeding.JohnWiley&Sons.GuptaSK.2005.PracticalPlantBreeding.Agribios. NarosaPublications,NewDelhi*
5. *SharmaJR.2001.PrinciplesandPracticeofPlantBreeding.TataMcGraw-Hill.*
6. *SharmaJP.2010.PrinciplesofVegetableBreeding.KalyaniPubl,NewDelhi.*
7. *SimmondsNW.1990.PrinciplesofCropImprovement.EnglishLanguageBookSociety.*

GPB 513 SEED PRODUCTION & CERTIFICATION 2 (1+1)

Objectives

To impart knowledge on principles of seed production and certification. This will help the students to understand seed production practices and seed certification procedures in different crops.

Theory

Importance of seed as basic input in agriculture; Seed quality concept and importance;Generationsystemofseedmultiplication-varietalreplacementrate,Seedmultiplicationratios,Seedreplacementrate,Seedrenewalperiodandseeddemandandsupply;Variousfactorsinfluencingseedproduction–PhysicalandGeneticpurityinseedproduction;Factorsresponsibleforvarietalandgeneticdeterioration.Nucleusseedproductionanditsmaintenance-Maintenanceofparentallinesofhybrids,Productionofbreeder,foundationandcertifiedseedandtheirqualitymaintenance; Principles of seed production in self- and cross-pollinated crops; Hybridseedproduction-systemandtechniquesinvolvedinSeedvillageconcept;Organicseedproductionandcertification.Principlesofseedproductioninfieldcrops;Floralstructure,pollinationmechanismandseedproductiontechniquesinself-andcross-pollinatedcerealsandmillets.Floralstructure,pollinationmechanismandmethodsandtechniquesofseedproduction in major pulses and oilseed crops; Varietal and hybrid seed productiontechniquesinPigeonpea,Mustard,CastorandSunflower.Floralstructure,pollination mechanismandmethodsandtechniquesofseedproduction in major commercial fibres. Hybrid-seed production techniques in majorvegetativelypropagatedcrops. Tissue culture plant seed production : NCSTCP; Seed certification - history, concept, objectives;Central seed certification board Seedcertification agency/ organization and staff requirement; Legal status - Phases ofseedcertification,formulation,revisionandpublicationofseedcertificationstandards;MinimumSeedCertificationStandards(MSCS)fordifferentcrops-Generalandspecificcropstandards,Fieldandseedstandards;Planningandmanagement of seed certification programs; Eligibility of a variety for certification,areaassessment,croppinghistoryoftheseedfield.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Importance of seed as basic input in agriculture; Seed quality concept and importance	1
2.	Generationsystemofseedmultiplication-Varietalreplacementrate,Seedmultiplicationratios,Seedreplacementrate,Seedrenewalperiodandseeddemandandsupply	1
3.	Variousfactorsinfluencingseedproduction–physicalandgeneticpurityinseedproduction, Factorsresponsibleforvarietalandgeneticdeterioration.	1
4.	Nucleusseedproductionanditsmaintenance-maintenanceofparentallinesofhybrids	1

5.	Productionofbreeder,foundationandcertifiedseedandtheirqualitymaintenance	1
6.	Principles of seed production in self- and cross-pollinated crops, Hybridseedproductionsystem	1
7.	Techniquesinvolvedinseedvillageconcept;organicseedproductionandcertification	1
8.	Principlesofseedproductioninfieldcrops;floralstructure pollinationmechanismandseedproductiontechniquesinself-andcross-pollinatedcerealsandmillets.	1
9.	Floral structure, pollination mechanism and methods and techniques of seed production in major pulses and oilseed crops	1
10.	Varietal and hybrid seed production techniques in Pigeon pea, mustard, castor and sunflower.	1
11.	Floralstructure,pollinationmechanismandmethodsandtechniquesofseedproduction in major commercial fibres.	1
12.	Hybrid-seed production techniques in majorvegetativelypropagatedcrops, Tissue culture plant seed production : NCSTCP	1
13.	Seed certification - history, concept, objectives, Central seed certification board Seed certification agency/ organization and staff requirement	1
14.	Legal status - phases of seed certification, formulation, revision and publication of seed certification standards;	1
15.	Minimum Seed Certification Standards (MSCS) for different crops - general and specific crop standards, field and seed standards	1
16.	Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.	1
Total		**16**

Practical

Planting design for variety- hybrid seed production techniques, planting ratio ofmale and female lines, synchronization of parental lines and methods to achievesynchrony;Identificationofroguesandpollenshedders,supplementarypollination,detasseling,handemasculationandpollination;
Pollencollectionandstoragemethods,pollenviabilityandstigmareceptivity;Pre-harvestsanitation,maturitysymptoms,harvestingtechniques;Visitstoseedproductionplots-visittoseedindustries;Planningforseedproduction:costbenefitratio,seedmultiplicationratioandseedreplacementrate;General procedure of seed certification, identification of weed and other crop
seedsasperspecificcrops,fieldinspectionatdifferentstagesofacropandobservationsrecorded on contaminants and reporting of results, inspection and sampling,harvesting / threshing, processing andafter processing forseed law enforcement;Specificationsfortagsandlabelstobeusedforcertificationpurpose.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Planting design for variety, hybrid seed production techniques,	1

2	Planting ratio ofmale and female lines synchronization of parental lines and methods to achievesynchrony	1
3	Identificationofroguesandpollenshedders	1
4	Supplementarypollination,detasseling	1
5	Handemasculationandpollination	1
6	Pollencollectionandstoragemethods	1
7	Pre-harvestsanitation,maturitysymptoms,harvestingtechniques	1
8	Visitstoseedproductionplots	1
9	Visittoseedindustries	1
10	Planningforseedproduction:costbenefitratio	1
11	Seedmultiplicationratioandseedreplacementrate	1
12	General procedure of seed certification	1
13	Identification of weed and other crop seedsasperspecificcrops,	1
14	Fieldinspectionatdifferentstagesofacropandobservationsrecorded on contaminants and reporting of results,	1
15	Inspection and sampling,harvesting/threshing, processing andafter processing forseed law enforcement	1
16	Specificationsfortagsandlabelstobeusedforcertificationpurpose	1
Total		**16**

Suggested Readings

1. *AgrawalPKandDadlaniM.1987.TechniquesinSeedScienceandTechnology,SouthAsianPublishers,Delhi.*
2. *AgrawalRL.1997.SeedTechnology,Oxford&IBHPublishing.*
3. *Anon,1965.FieldInspectionManualandMinimumSeedCertificationStandards,NSCPublication,NewDelhi.*
4. *Anon.1999.ManualofSeedCertificationprocedures.DirectorateofSeedCertification,Coimbatore,TamilNadu.*
5. *JoshiAKandSinghBD.2004.SeedScienceandTechnology,KalyaniPublishers,NewDelhi. KellyAF.1988.SeedProductionofAgriculturalCrops.JohnWiley,NewYork.*
6. *McDonaldMBandCopelandLO.1997.SeedScienceandTechnology,ScientificPublisher,Jodhpur.*
7. *RamamoorthyK,SivasubramaniamKandKannanM.2006.SeedLegislationinIndia.Agrobios(India),Jodhpur,Rajasthan.*
8. *SinghalNC.2003. HybridSeedProductioninFieldCrops,KalyaniPublications,NewDelhiTunwarNSandSinghSV.1988.IndianMinimumSeedCertificationStandards.CentralSeed*
9. *CertificationBoard,MinistryofAgriculture,NewDelhi.*
10. ***e-Resources****www.gov.mb.cawww.agricoop.nic.inwww.agri.nic.inwww.fao.orgwww.sednet.gov.in*

GPB 514 VARIETAL DEVELOPMENT & MAINTENANCE BREEDING 2 (1+1)

Objectives

The purpose of this course is to make students well acquainted with the techniques and procedures of varietal development. He will be associated with development of variety so the course aims is to provide knowledge on DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids

Theory

Variety Development systems and Maintenance; Definition- variety, cultivar, extantvariety, essentially derived variety, independently derived variety, reference variety,farmers'variety,landraces,hybrid,andpopulation;Varietytesting,releaseandnotificationsystemsandnormsinIndiaandabroad.DUStesting, DUSDescriptorsformajorcrops;Geneticpurityconceptandmaintenance breeding. Factors responsible for genetic deterioration of varieties-safeguardsduringseedproduction.Maintenanceofvarietiesinselfandcrosspollinatedcrops,isolationdistance;Principlesofseedproduction;Methodsofnucleusandbreederseedproduction;Generationsystemofseedmultiplication-nucleus,breeders,foundation,certified.Qualityseedproductiontechnologyofselfandcross-pollinatedcropvarieties,viz.,cerealsandmillets(wheat,barley,paddy,pearlmillet,sorghum,maizeandragi,etc.);Pulses(greengram,blackgram,cowpea,pigeonpea,chickpea,fieldpea,lentil);Oilseeds (groundnut, soybean, sesame, castor, linseed, rapeseedandmustard);fibres(cotton)andforages(guar,foragesorghum, oats,berseem,lucerne).Seedcertificationprocedures;Seedlawsandacts,plantvarietyprotectionregulationsin Indiaandinternationalsystems.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Variety development systems and maintenance	1
2.	Definition- variety, cultivar, extantvariety, essentially derived variety, independently derived variety, reference variety,farmers'variety,landraces,hybrid,andpopulation	1
3.	Varietytesting,releaseandnotificationsystemsandnormsinIndiaand abroad.	1
4.	DUStesting-DUSDescriptorsformajorcrops	1
5.	Geneticpurityconceptandmaintenance breeding	1
6.	Factors responsible for genetic deterioration of varieties-safeguardsduringseedproduction	1
7.	Maintenanceofvarietiesinselfandcrosspollinatedcrops	1
8.	Isolationdistance;Principlesofseedproduction;Methodsofnucleusandbreederseedproduction	1
9.	Generationsystemofseedmultiplication-nucleus,breeders,foundation,certified	1
10.	Qualityseedproductiontechnologyofselfandcross-pollinatedcropvarieties,*viz*.,cerealsandmillets(wheat,barley,paddy,Pearlmillet,sorghum,maizeandragietc.)	2
11.	Pulses(greengram,blackgram,cowpea,pigeonpea,chickpea,fieldpea,lentil)	1
12.	Oilseeds (groundnut, soybean, sesame, castor, linseed,	1

	rapeseedandmustard)	
14.	Fibres(cotton)andforages(guar,foragesorghum, oats,berseem andlucerne).	1
15.	Seedcertificationprocedures;Seedlawsandacts	1
16.	Plantvarietyprotectionregulationsin Indiaandinternationalsystems.	1
Total		**16**

Practical

Identificationofsuitableareas/locationsforseedproduction;Ear-to-rowmethodandnucleusseedproduction;Maincharacteristicsofreleasedandnotifiedvarieties,hybridsandparentallines;PGMSandTGMS;Identificationofimportantweeds/objectionableweeds;Determinationofisolationdistanceandplantingratiosindifferentcrops;Seedproductiontechniquesofvarietiesindifferentcrops;Hybridseedproductiontechnologyofimportantcrops;DUStestinganddescriptorsinmajorcrops;Varietyreleaseproposalformatsindifferentcrops

Lecture Schedule - Practical

S. No.	Topics	No. of Lectures
1.	Identificationofsuitableareas/locationsforseedproduction	1
2.	Ear-to-rowmethod	1
3.	Nucleusseedproduction	1
4.	Maincharacteristicsofreleasedandnotifiedvarieties,	1
5.	Maincharacteristicsofreleasedandnotifiedvarieties - hybridsandparentallines	1
6.	PGMSandTGMS	1
7.	Identificationofimportantweeds/objectionableweeds	1
8.	Determinationofisolationdistanceandplantingratiosindifferentcrops	1
9.	Seedproductiontechniquesofvarietiesindifferentcrops	2
10.	Hybridseedproductiontechnologyofimportantcrops	2
11.	DUStesting	1
12.	Descriptorsinmajorcrops	2
13.	Varietyreleaseproposalformatsindifferentcrops	1
Total		**16**

Suggested Readings

1. *Agarwal RL. 1997. Seed Technology. 2nd Ed. OXford & IBH.*
2. *Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.*
3. *McDonald MB Jr and Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.*
4. *Poehlman JM and Borthakur D. 1969. Breeding Asian Field Crops. OXford & IBH.*
5. *Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani. 2015*
6. *Thompson JR. 1979. An Introduction to Seed Technology. Leonard.*
7. *Singh DP, Singh AK and Singh A.2021.Plant Breeding and Cultivar Development, Elsevier*

GPB 521PRINCIPLES OF CYTOGENETICS 3 (2+1)

Objectives

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution

Theory

Cell cycle and architecture of chromosome in prokaryotes and eukaryotes, Chromonemata, chromosome matrix, chromomeres, centromere, secondaryconstrictionandtelomere;artificialchromosomeconstructionanditsuses;Specialtypes of chromosomes.Variation in chromosome structure: Evolutionary significance;Introductiontotechniquesforkaryotyping;Chromosomebandingandpainting-*Insitu*hybridizationandvariousapplications.Structural and numerical variations of chromosomes and their implications; Symbolsandterminologiesforchromosomenumbers,euploidy,haploids,diploidsandpolyploids;Utilizationofaneuploidsingenelocation;Variationinchromosomebehaviour,somaticsegregationandchimeras,endomitosisandsomaticreduction;Evolutionarysignificanceofchromosomalaberrations, balancedlethalandchromosomecomplexes;Inter-varietalchromosomesubstitutions.Fertilizationbarriersincropplantsatpre andpostfertilizationlevels;*In-vitro*techniquestoovercomethefertilizationbarriersincrops;Polyploidy.Geneticconsequences of polyploidization and role of polyploids in crop breeding; Evolutionaryadvantages of autopolyploid vs. allopolyploids; Role of aneuploids in basic and appliedaspectsofcropbreeding,theirmaintenanceandutilizationingenemappingandgene blocks transfer; Alien addition and substitution lines, creation and utilization;Apomixis,evolutionaryandgeneticproblemsincropswithapomixes.Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecifichybridizationandallopolyploids;Synthesisofnewcrops(wheat,*Triticale,Brassica***,**and cotton);Hybridsbetweenspecieswithsamechromosomenumber,alientranslocations;Hybridsbetweenspecieswithdifferentchromosomenumber;Genetransferusingamphidiploids,bridgespecies.Chromosomemanipulationsinwidehybridization;casestudies;Productionanduseofhaploids,dihaploidsanddoubledhaploidsingeneticsandbreeding.

Lecture Schedule - Theory

S. No.	Topics	No. of lectures
1.	Cell cycle and architecture of chromosome in prokaryotes and eukaryotes	1
2.	Chromonemata, chromosome matrix, chromomeres, centromere, secondaryconstrictionandtelomere;	1
3.	Artificialchromosomeconstructionanditsuses	1
4.	Specialtypes of chromosomes	1
5.	Variation in chromosome structure: Evolutionary significance	1
6.	Introductiontotechniquesforkaryotyping;Chromosomebandingandpainting	1
7.	*In-situ*hybridizationandvariousapplications	1
8.	Structural and numerical variations of chromosomes and their implications	2
9.	Symbolsandterminologiesforchromosomenumbers,euploidy,haploids,diploidsand polyploids	1
10.	Utilizationofaneuploidsingenelocation	1

11.	Variationinchromosomebehaviour,somaticsegregationandchimeras	1
12.	Endomitosisandsomaticreduction	1
13.	Evolutionarysignificanceofchromosomalaberrations,balancedlethalandchromosomecomplexes;Inter-varietalchromosomesubstitutions	1
14.	Fertilizationbarriersincropplantsatpre-andpost fertilizationlevels	1
15.	*In-vitro*techniquestoovercomethefertilizationbarriersincrops;Polyploidy	1
16.	Geneticconsequences of polyploidization and role of polyploids in crop breeding;	1
17.	Evolutionaryadvantages of autopolyploid vs. allopolyploids	1
18.	Role of aneuploids in basic and appliedaspectsofcropbreeding theirmaintenanceandutilizationingenemappingandgene blocks transfer	2
19.	Alien addition and substitution lines, creation and utilization	1
20.	Apomixis,	1
21.	Evolutionaryandgeneticproblemsincropswithapomixis	1
22.	Reversion of autopolyploid to diploids	1
23.	Genome mapping in polyploids	1
24.	Interspecifichybridizationandallopolyploids	1
25.	Synthesisofnewcrops(wheat,*Triticale*,*Brassica*,andcotton)	1
26.	Hybridsbetweenspecieswithsamechromosomenumber,alientranslocations	1
27.	Hybridsbetweenspecieswithdifferentchromosomenumber	1
28.	Genetransferusingamphidiploids,bridgespecies	1
29.	Chromosomemanipulationsinwidehybridization;casestudies	1
30.	Productionanduseofhaploids,dihaploidsanddoubledhaploidsingeneticsandbreeding	1
Total		**32**

Practical

Learningthecytogeneticallaboratorytechniques,variouschemicalstobeusedforfixation,dehydration,embedding,staining,cleaning,etc.;Microscopy:varioustypesofmicroscopes;Preparingspecimenforobservation;Fixativepreparationandfixingspecimenforlightmicroscopystudiesincereals;Studiesonmitosisandmeiosisincropplants;Usingmicrometresandstudyingthepollengrainsizeinvariouscrops.Pollengermination*invivo*and*in-vitro*;Demonstrationofpolyploidy.

Lecture Schedule - Practical

S. No.	Topics	No. of lectures
1.	Learningthecytogeneticallaboratorytechniques	2
2.	Variouschemicalstobeusedforfixation, dehydration, embedding,staining,cleaning,etc.	2
3.	Microscopy:varioustypesofmicroscopes;	1
4.	Preparingspecimenforobservation	2
5.	Fixativepreparationandfixingspecimenforlightmicroscopystudies incereals	2
6.	Studiesonmitosis incropplants	1
7	Studiesonmeiosisincropplants	1
8.	Usingmicrometresandstudyingthepollengrainsizeinvariouscrops	2
9.	Pollengermination*invivo*	1
10.	Pollengermination*invitro*	1
11.	Demonstrationofpolyploidy	1
Total		**16**

Suggested Readings

1. *Becker K and Hardin J. 2004. World of the Cell. 5th Ed. Pearson Edu. 9th edition.CarrollM.1989.Organelles. TheGuilfordPress.*
2. *Charles B. 1993.DiscussionsinCytogenetics.PrenticeHallPublications.*
3. *Darlington CD and La Cour LF. 1969. The Handling of Chromosomes. George Allen & UnwinLtd.*
4. *ElginSCR.1995.ChromatinStructureandGeneExpression.IRLPress,Oxford.*
5. *Gupta PK and Tsuchiya T. 1991. Chromosome Engineering in Plants: Genetics, Breeding andEvolution.PartA.*
6. *GuptaPK.2010.Cytogenetics.RastogiPubishers.*
7. *JohannsonDA.1975.PlantMicrotechnique.McGrawHill.*
8. *KarpG.1996.CellandMolecularBiology:ConceptsandExperiments.JohnWiley&Sons.*
9. *KhushGS.1973.Cytogeneticsofaneuploids.Elsevier.1edition.*
10. *RoyD.2009.Cytogenetics.AlphaScienceIntlLtd.*
11. *SchulzSJ.1980.Cytogenetics-Plant,animalsandHumans.Springer.*
12. *SharmaAKandSharmaA.1988.ChromosomeTechniques:TheoryandPractice.Butterworth -Heinemannpublisher2014.3rd edition*
13. *SinghRJ.2016.PlantCytogenetics3rdEdition.CRCPress.*
14. *SumnerAT. 1982.Chromosome Banding.UnwinHyman Publ.1edition,Springer pub.*
15. *SwansonCP.1960.CytologyandCytogenetics.Macmillan&Co.*

GPB 522 FUNDAMENTALS OF QUANTITATIVE GENETICS3 (2+1)

Objectives

To impart theoretical knowledge and computation skills regarding components of variation and variances, scales, mating designs and gene effect.

Theory

Introductionandhistoricalbackgroundofquantitativegenetics,Multiplefactorhypothesis, Qualitative and quantitative characters, Analysis of continuous variationmean,range,SD,CV;Componentsofvariation-Phenotypic,Genotypic,Natureofgeneaction-additive,dominanceandepistatic,linkageeffect.Principlesofanalysis ofvarianceandlinearmodel,Expectedvariancecomponents,Randomandfixedeffectmodel,Comparisonofmeansandvariancesforsignificance.Designsforplantbreedingexperiments-principlesandapplications;Variabilityparameters,conceptofselection,simultaneousselectionmodesandselectionofparents,MANOVA.Associationanalysis-Genotypicandphenotypiccorrelation,PathanalysisDiscriminate function and principal component analysis, Genetic divergence analysis-MetroglyphandD^2,Generationmeananalysis,Parentprogenyregressionanalysis, G × E interaction-Adaptability andstability; Methods and models for stability analysis; Basic models- principles andinterpretation,Bi-plotanalysis. Matingdesigns-classification,Diallel,partialdiallel,L×T,NCDsandTTC;Concept of combining ability and gene action. QTLmapping,StrategiesforQTLmapping- Mapping populationandstatisticalmethods,QTLmappingingeneticanalysis;Markers, Marker assisted selectionandfactorsinfluencingtheMAS,Simultaneousselectionbasedonmarkerandphenotype.

Lecture Schedule - Theory

S. No.	Topics	No. of lectures
	Introductionandhistoricalbackgroundofquantitativegenetics	1
	Multiplefactorhypothesis	1
	Qualitative and quantitative characters	1
	Analysis of continuous variationmean,range,SD,CV	1
	Componentsofvariation-Phenotypic,Genotypic	1
	Natureofgeneaction-additive,dominanceandepistatic,linkageeffect	1
	Principlesofanalysis ofvarianceandlinearmodel	2
	Expectedvariancecomponents,Randomandfixedeffectmodel	1
	Comparisonofmeansandvariancesforsignificance	1
	Designsforplantbreedingexperiments-principlesandapplications	1
	Variabilityparameters	1
	Conceptofselection,simultaneousselectionmodesandselectionofparents	1
	MANOVA	1
	Associationanalysis-Genotypicandphenotypiccorrelation	1
	Pathanalysis	1
	Discriminate function and principal component analysis	1
	Genetic divergence analysis-MetroglyphandD^2	1
	Generationmeananalysis	1
	Parentprogenyregressionanalysis	1
	G × E interaction Adaptability andstability	1
	Methods and models for stability analysis	1
	Basic models- principles andinterpretation	1

	Bi-plotanalysis	1
	Matingdesigns-classification, Diallel,partialdiallel	1
	Matingdesigns-L×T	1
	Matingdesigns-NCDs,andTTC	1
	Concept of combining ability and gene action	1
	QTLmapping	1
	StrategiesforQTLmapping- Mapping populationandstatisticalmethods	1
	QTLmappingingeneticanalysis	1
	Markers, Marker assisted selectionandfactorsinfluencingtheMAS,Simultaneousselectionbasedonmarkerandphenotype	2
Total		**32**

Practical

Analysisandinterpretationofvariabilityparameters;
AnalysisandinterpretationofIndexscoreandMetroglyph;
ClusteringandinterpretationofD^{2}analysis;
Genotypicandphenotypiccorrelationanalysisandinterpretation;
Pathcoefficientanalysisandinterpretation,Estimationofdifferenttypesofheterosis,inbreeding depressionandinterpretation; A,BandCScalingtest; L×Tanalysisandinterpretation,QTLanalysis; Useofcomputerpackages; Diallelanalysis; G×Einteractionandstabilityanalysis.

Lecture Schedule - Practical

S. No.	Topics	No. of lectures
1.	Analysisandinterpretationofvariabilityparameters andMetroglyph	2
2.	ClusteringandinterpretationofD^{2}analysis	2
3.	Genotypicandphenotypiccorrelationanalysisandinterpretation	1
4.	Pathcoefficientanalysisandinterpretation	2
5.	Estimationofdifferenttypesofheterosis inbreedingdepressionandinterpretation	1
6.	A,BandCScalingtest	1
7.	L×Tanalysisandinterpretation	1
8.	QTLanalysis	1
9.	Useofcomputerpackages	1
10.	Diallelanalysis	2
11.	G×Einteractionandstabilityanalysis	2
Total		**16**

Suggested Readings

1. *BosIandCaligariP.1995.SelectionMethodsinPlantBreeding.Chapman&Hall.*

2. *Falconer DS and MackayJ.1998.IntroductiontoQuantitativeGenetics(3rdEd.).ELBS/Longman,London.*
3. *MatherKandJinksJL.1985.BiometricalGenetics(3rdEd.).ChapmanandHall,London.*
4. *NandarajanNandGunasekaranM.2008.QuantitativeGeneticsandBiometricalTechniquesinPlantBreeding.KalyaniPublishers,NewDelhi.*

5. *NaryananSSandSinghP.2007.BiometricalTechniquesinPlantBreeding.KalyaniPublishers,NewDelhi.*
6. *RoyD.2000.PlantBreeding:AnalysisandExploitationofVariation.NarosaPublishingHouse,NewDelhi.*
7. *SharmaJR.2006.StatisticalandBiometricalTechniquesinPlantBreeding.NewAgeInternationalPvt.Ltd.*
8. *SinghP.andNarayananSS.1993.BiometricalTechniquesinPlantBreeding.KalyaniPublishers,NewDelhi.*
9. *SinghRK.andChaudharyBD.1987.BiometricalMethodsinQuantitativeGeneticanalysis.KalyaniPublishers,NewDelhi.*
11.WeirDS.1990.GeneticDataAnalysis.MethodsforDiscretePopulationGenetic Data.SinauerAssociates.
12.WrickeG.andWeberWE.1986.QuantitativeGeneticsandSelectioninPlant Breeding.WalterdeGruyter.
13.e-SuggestedReading: www.iasri.icar.gov.inwww.hau.ac.in/OPstat

GPB 523 MUTAGENESIS & MUTATION BREEDING3 (2+1)

Objectives

To impart the knowledge about general principles of mutagenesis for crop improvement and various tests/ methods for detection of mutations.

Theory

Mutation and its history, nature and classification of mutations: spontaneous andinduced mutations, micro and macro mutations, pre and post adaptive mutations;Detectionofmutations.Paramutationsincropsplants. Mutagenicagents:physical–radiationtypesandsources:Ionizingandnon-ionizingradiations. Radiobiology: mechanism of action of various radiations (photoelectricabsorption, compton scattering and pair production) and their biological effects – RBEandLETrelationships;EffectofmutationsonDNA–repairmechanismsoperating at DNA, chromosome, cell and organism level to counteract the mutationeffects; Dosimetry-objects and methods of treatment; Factors influencing mutation:doserate,acute*vs.*chronicirradiation,recurrentirradiation,enhancementofthermalneutron effects; Radiation sensitivity and modifying factors: External and internalsources–Oxygen,watercontent,temperatureandnuclearvolume.Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents,acridinedyesandothermutagens:theirpropertiesandmodeofaction;Dosedetermination and factors influencing chemical mutagenesis; Treatment methodsusing physical and chemical mutagens, Combination treatments; other causes ofmutation–

directandindirectaction,comparativeevaluationofphysicalandchemicalmutagens. ObservingmutageneffectsinM$_1$generation:plantinjury,lethality,sterility,chimeras,etc.;ObservingmutageneffectsinM_2generation;Estimationofmutagenicefficiencyandeffectiveness-spectrumofchlorophyllandviablemutations;Mutationsintraitswithcontinuousvariation;Factorsinfluencingthemutantspectrum:genotype,typeofmutagenanddose,pleiotropyandlinkage,etc.;Individualplantbasedmutationanalysisandworkingouteffectivenessandefficiency in M_3 generation; Comparative evaluation of physical and chemical mutagens forcreationofvariabilityinthesomespecies-Casestudies.Use of mutagens in creating oligogenic and polygenic variations – Case studies; *In-vitro*mutagenesis – Callus and pollen irradiation; Handling of segregating M_2 generationsand selection procedures; Validation of mutants; Mutation breeding for various traits(diseaseresistance,insectresistance,qualityimprovement,etc.)indifferentcrops;Proceduresformicromutationsbreeding/polygenicmutations;Achievementsofmutationbreeding-varietiesreleasedacrosstheworld,problemsassociatedwithmutationbreeding.Useofmutagensingenomics,allelemining,TILLING.

Lecture Schedule - Theory

S. No.	Topics	No. of lectures
1.	Mutation and its history, nature and classification of mutations	1
2.	Spontaneous andinduced mutations, micro and macro mutations, pre and post adaptive mutations	1
3.	Detectionofmutations	1
4.	Paramutationsincropsplants	1
5.	Mutagenicagents:physical–radiationtypesandsources Ionizingandnon-ionizingradiations	1
6.	Radiobiology: mechanism of action of various radiations (photoelectricabsorption, Compton scattering and pair production) and their biological effects –RBEandLETrelationships	1
7.	EffectofmutationsonDNA–repairmechanismsoperating at DNA, chromosome, cell and organism level to counteract the mutationeffects	1
8.	Dosimetry -Objects and methods of treatment	1
9.	Factors influencing mutation:doserate,acute*vs.*chronicirradiation,recurrentirradiation,enhancementofthermalneutron effects	1
10.	Radiation sensitivity and modifying factors: External and internalsources–Oxygen,watercontent,temperatureandnuclearvolume.	1
11.	Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents,acridinedyesandothermutagens:theirpropertiesandmodeofaction;Dosedetermination and factors influencing chemical mutagenesis	2
12.	Treatment methodsusing physical and chemical mutagens	1
13.	Combination treatments; other causes ofmutation–directandindirectaction	1
14	Comparativeevaluationofphysicalandchemicalmutagens	1

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15.	Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras, etc.	1
16.	Observing mutagen effects in M_2 generation	1
17.	Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations	1
18.	Mutations in traits with continuous variation	1
19.	Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.	1
20.	Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation	1
21.	Comparative evaluation of physical and chemical mutagens for creation of variability in the some species - Case studies	1
22.	Use of mutagens in creating oligogenic and polygenic variations – Case studies	1
23.	*In-vitro* mutagenesis – Callus and pollen irradiation	1
24.	Handling of segregating M_2 generations and selection procedures	1
25.	Validation of mutants	1
26.	Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops	1
27.	Procedures for micro mutations breeding/polygenic mutations	1
28.	Achievements of mutation breeding - varieties released across the world	1
29.	Problems associated with mutation breeding	1
30.	Use of mutagens in genomics	1
31.	Allele mining and TILLING	1
Total		32

Practical

Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents: Physical mutagens and Chemical mutagens; Learning on Radioactivity-Production source and isotopes at BRIT, Trombay, Learning about gamma chamber; Radiation hazards: Monitoring–safety regulations and safe transportation of radioisotopes, visit to radioisotope laboratory; learning on safe disposal of radioisotopes; Hazards due to chemical mutagens–Treating the plant propagules at different doses of physical and chemical mutagens; Procedures in combined mutagenic treatments; Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature; Study of M_1 generation–

Parameters;StudyofM_2generation–Parameters;Mutationbreedingincerealsandpulses-achievementsmadeandananalysis;Mutationbreedinginoilseedsandcotton-achievementsandopportunities;Mutationbreedinginforagecropsandvegetativelypropagatedcrops;ProcedurefordetectionofmutationsforpolygenictraitsinM_2andM_3generations.

Lecture Schedule - Practical

S. No.	Topics	No. of lectures
1	Precautions on handling of mutagens	1
2	Dosimetry-Studies of different mutagenicagents	1
3	PhysicalmutagensandChemicalmutagens	1
4	Learning on Radioactivity- Production source and isotopes at BRIT, Trombay,Learningaboutgammachamber	1
5	Radiationhazards:Monitoring–safetyregulationsandsafetransportationofradioisotopes	1
6	Visittoradioisotopelaboratory	1
7	Learningonsafedisposalofradioisotopes	1
8	Hazards due to chemical mutagens – Treating the plant propagules at differentdosesofphysicalandchemicalmutagens	1
9	Procedures in combined mutagenictreatments	1
10	Raising the crop for observation; Mutagenic effectiveness and efficiency, calculatingthesamefromearlierliterature	1
11	StudyofM_1generation–Parameters	1
12	StudyofM_2generation–Parameters	1
13	Mutationbreedingincerealsandpulses-achievementsmadeandananalysis	1
14	Mutationbreedinginoilseedsandcotton-achievementsandopportunities	1
15	Mutationbreedinginforagecropsandvegetativelypropagatedcrops	1
16	ProcedurefordetectionofmutationsforpolygenictraitsinM_2andM_3generations	1
Total		**16**

Suggested Readings

1. *AlperT.1979.CellularRadiobiology.CambridgeUniv.Press,London.*
2. *ChadwickKHandLeenhoutsHP.1981.TheMolecularTheoryofRadiationBiology.Springer-Verlag.*
3. *CottonR,EdkinEandForrestS.2000.MutationDetection:APracticalApproach.OxfordUniv.Press.InternationalAtomicEnergyAgency.1970.*
4. *ManualonMutationBreeding.InternationalAtomicEnergeyAgency,Vienna,Italy.*
5. *ShuQY,ForsterBPandNakagawaN.2012.PlantMutationBreedingandBiotechnology.*
6. *GutecnbergPressLtd.RomeItalyISBN:978-925107-022-2(FAO).*
7. *SinghBD.2003.Genetics.KalyaniPublishers,NewDelhi.Strickberger MW. 2005. Genetics. 3rd Ed. Prentice Hall.www.barc.gov.in*

GPB 524 HYBRID BREEDING 3 (2+1)

Objectives

To provide knowledge of understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

Theory

Historicalaspect of heterosis,nomenclature and definitionsof heterosis; Heterosisinnaturalpopulationandinbredpopulation;Evolutionaryaspects– Geneticconsequencesofselfing,sibbingandcrossinginself-andcross-pollinatedandasexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionaryconceptsofheterosis;Genetictheoriesofheterosis– physiological,biochemicalandmolecularfactorsunderlininheterosis;theoriesandtheirestimation; Biometricalbasisofheterosis.Predictionofheterosisfromvariouscrosses,inbreedingdepression,coefficientofinbreeding and its estimation, residual heterosis in F_2 and segregating populations,importanceofinbreedinginexploitationofheterosis–casestudies.Relationshipbetween genetic distance and expression of heterosis, case studies; Divergence andgenetic distance analyses, morphological and molecular genetic distance in predictingheterosis; Development of heterotic pools in germplasm/genetic stocks and inbreeds,theirimprovementforincreasingheterosis.Malesterilityanduseinheterosisbreeding;Malesterilelinecreationanddiversificationinself-pollinated,crosspollinatedandasexuallypropagatedcrops;Creation of male sterility through geneticengineering and its exploitation inheterosis, Maintenance,transferandrestorationofdifferenttypesofmalesterility;Useofself-incompatibilityindevelopmentofhybrids.Hybridseedproductionsystem:3-line,2-lineand1-linesystem;Developmentofinbreeds and parental lines- A, B and R lines-functional male sterility;

Commercialexploitationofheterosis,maintenancebreedingofparentallinesinhybrids;Fixation ofheterosisinself,crossandoftencrosspollinatedcrops,asexually/clonallypropagatedcrops,problemsandprospects;Apomixisinfixingheterosis-conceptofsinglelinehybrid;Organellarheterosisandcomplementation.Hybridbreedinginwheat,rice,cotton,maize,pearlmillet,sorghumandrapeseed-mustard andcastoroilseedcropsandpigeonpea.

Lecture Schedule - Theory

S. No.	Topics
1.	Historicalaspect of heterosis
2.	Nomenclature and definitionsof heterosis
3.	Heterosisinnaturalpopulationandinbredpopulation
4.	Evolutionaryaspects–Geneticconsequencesofselfing,sibbingandcrossinginself-andcross-

	pollinatedandasexually propagated crops
5.	Pre-Mendelian and Post-Mendelian ideas – Evolutionaryconceptsofheterosis
6.	Genetictheoriesofheterosis–physiological,biochemicalandmolecularfactorsunderliningheterosis
7.	Theoriesandtheirestimation;Biometricalbasisofheterosis
8.	Predictionofheterosisfromvariouscrosses,inbreedingdepression,coefficientofinbreeding and its estimatio
9.	Residual heterosis in F_2 and segregating populations,importanceofinbreedinginexploitationofheterosis– casestudies
10.	Relationshipbetween genetic distance and expression of heterosis, case studies
11.	Divergence andgenetic distance analyses, morphological and molecular genetic distanc predictingheterosis
12.	Development of heterotic pools in germplasm/ genetic stocks and inbreeds,theirimprovementforincreasingheterosis
13.	Malesterilityanduseinheterosisbreeding
14.	Malesterilelinecreationanddiversificationinself-pollinated,crosspollinatedandasexuallypropagatedc
15.	Creation of male sterility through genetic engineering and its exploitation in heterosis
16.	Maintenance,transferandrestorationofdifferenttypesofmalesterility
17.	Useofself-incompatibilityindevelopmentofhybrids
18.	Hybridseedproductionsystem:3-line,2-lineand1-linesystem
19.	Developmentofinbreeds and parental lines- A, B and R lines – functional male sterility
20.	Commercialexploitationofheterosis,maintenancebreedingofparentallinesinhybrids
21.	Fixation ofheterosisinself,crossandoftencrosspollinatedcrops,asexually/clonallypropagatedcrops,problemsandpro
22.	Apomixisinfixingheterosis-conceptofsinglelinehybrid
23.	Organellarheterosisandcomplementation
24.	Hybridbreedinginwheat
25.	Hybridbreedinginrice
26.	Hybridbreedingincotton
27.	Hybridbreedinginmaize
28.	Hybridbreedinginpearlmillet
29.	Hybridbreedinginsorghum
30.	Hybridbreedinginrapeseed-mustard
31.	Hybridbreedingincastoroilseedcrops
32.	Hybridbreedinginpigeonpea.
Total	

Practical

Characterizationofmalesterilelinesusingmorphologicaldescriptors;
Restorerlineidentificationanddiversificationofmalesterilesources;
Malesterilelinecreationincropplants,problemsincreationofCGMSsystem,waysofovercomingthe m, Diversificationandrestoration;
SuccessstoriesofhybridbreedinginMaize,Rice,Pearlmillet,Sorghum& Pigeonpea;
Understandingthedifficultiesinbreedingapomicts;
Estimationofheteroticparametersinself,crossandasexuallypropagatedcrops;
Estimationfromthevariousmodelsforheterosisparameters;
Hybridseedproductioninfieldcrops—
anaccountonthereleasedhybrids,theirpotential,problemsandwaysofovercomingit;
HybridbreedingatNationalandInternationallevel,opportunitiesahead.

Lecture Schedule - Practical

S. No.	Topics	No. of lectures
1.	Characterizationofmalesterilelinesusingmorphologicaldescriptors	1
2.	Restorerlineidentificationanddiversificationofmalesterilesources	1
3.	Malesterilelinecreationincropplants	2
4.	ProblemsincreationofCGMSsystem,waysofovercomingthem	1
5.	Diversificationandrestoration	1
6.	Successstoriesofhybridbreedinginmaize	1
7.	Successstoriesofhybridbreeding inpigeonpeaand rice	1
8.	Successstoriesofhybridbreedingin pearlmillet andsorghum	1
9.	Understandingthedifficultiesinbreedingapomicts	1
10.	Estimationofheteroticparametersinself,crossandasexuallypropagated crops	1
11.	Estimationfromthevariousmodelsforheterosisparameters	2
12.	Hybridseedproductioninfieldcrops - anaccountonthereleasedhybrids,theirpotential,problemsandwaysofovercomingit	2
13.	Hybridbreedingatnationalandinternationallevel,opportunitiesahead	1
Total		**16**

Suggested Readings

1. *AgarwalRL.1998.FundamentalofPlantBreedingandhybridSeedProduction.SciencePublisherLondon.*
2. *AkinE.1979.TheGeometryofPopulationGenetics.Springer-Verlag.*
3. *BenHL.1998.StatisticalGenomics–Linkage,MappingandQTLAnalysis.CRCPress.*
4. *ChalGSandGossalSS.2002.PrinciplesandproceduresofPlantBreeding,Biotechnologyand ConvetionalApproaches.NarosaPublishingHouse.NewDelhi*
5. *De JG. 1988. Population Genetics and Evolution. Springer-Verlag. 30 January 2012HartlDL.2000.APrimerofPopulationGenetics.3rdEd.SinauerAssoc.*
6. *MettlerLEandGreggTG.1969.PopulationGeneticsandEvolution.Prentice-Hall.25April1988*
7. *MontgomeryDC.2001.DesignandAnalysisofExperiments.5thEd.,Wiley&Sons.2013MukherjeeBK.1995.TheHeterosisPhenomenon.KalyaniPublishers,NewDelhi.*
8. *ProceedingsofGeneticsandExploitationofHeterosisinCrops–AnInternationalSymposiumCIMMYT,1998.*
9. *Richards AJ.1986. PlantBreedingSystems.GeorgeAllen&Unwin.30May1997SinghBD.2006.PlantBreeding.KalyaniPublishers,NewDelhi.*
10. *SrivastavaSandTyagiR.1997.SelectedProblemsinGenetics.Vols.I,II.AnmolPubl.Virmani SS.1994.HeterosisandHybridRice Breeding.Monographsof"TheoreticalandAppliedGenetics",Springer-Verlag.*

GPB 525 BREEDING FOR STRESS RESISTANCE & CLIMATE CHANGE3 (2+1)

Objectives

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and methods to breed stress tolerant varieties.

Theory

Conceptandimpactofclimaticchange;Importanceofplantbreedingwithspecialreferencetobioticand abioticstressresistance;Classificationofbioticstresses– majorpestsanddiseasesofeconomicallyimportantcrops.Conceptsofresistancetoinsectandpathogen resistance;Analysisandinheritanceofresistancevariation;Hostdefenceresponsestopathogeninvasi ons-Biochemicaland molecular mechanisms; Acquired and induced immunity and systemic acquiredresistance(SAR);Host-pathogeninteraction,gene-for-genehypothesis,molecularevidence for its operation and exceptions; Concept of signal transduction and otherhost-defencemechanismsagainstvirusesandbacteria.Typesandgeneticmechanismsofresistancetobio ticstresses-Horizontalandverticalresistanceincropplants;Quantitativeresistance/adultplantresistanceand slow rusting resistance; Classical and molecular breeding methods-Measuringplantresistanceusingplantfitness;Behavioural,physiologicalandinsectgainstudies; Phenotypic screening methods for major pests and diseases; Recording ofobservations; Correlating the observations using marker data – Gene pyramidingmethodsandtheirimplications.Classificationofabioticstresses-Stressinducingfactors,moisturestress/droughtandwaterloggingandsubmergence;Acidity,salinity/ alkalinity/sodicity;High/low temperature, wind, etc.; Stress due to soil factors and mineral toxicity;Physiological and Phenological responses; Emphasis of abiotic stresses in developingbreedingmethodologies.Geneticsofabioticstressresistance;Genesandgenomicsinbr eedingcultivarssuitable to low water regimes and water logging and submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types inimportant crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance tostresses caused by toxicity, deficiency and pollutants/ contaminants in soil, waterandenvironment. Use of crop wild relatives as a source of resistance to biotic and abiotic factors inmajor field crops; Transgenics in management of biotic and abiotic stresses, use oftoxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pestmanagement.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Conceptandimpactofclimaticchange	1
2.	Importanceofplantbreedingwithspecial referencetobioticandabioticstressresistance	1
3.	Classificationofbioticstresses– majorpestsanddiseasesofeconomicallyimportantcrops.	1
4.	Conceptsofresistancetoinsectandpathogenresistance	1
5.	Analysisandinheritanceofresistancevariation	1
6.	Hostdefenceresponsestopathogeninvasions-Biochemical and molecular mechanisms	1
7.	Acquired and induced immunity and systemic acquiredresistance(SAR)	1

8.	Host-pathogeninteraction,gene-for-genehypothesis,molecularevidence for its operation and exceptions	1
9.	Concept of signal transduction and otherhost-defencemechanismsagainstvirusesandbacteria	1
10.	Typesandgeneticmechanismsofresistancetobioticstresses–Horizontalandverticalresistanceincropplants	1
11.	Quantitativeresistance/adultplantresistanceand slow rusting resistance	1
12.	Classical and molecular breeding methods - Measuringplantresistanceusingplantfitness	1
13.	Behavioural,physiologicalandinsectgainstudies	1
14.	Phenotypic screening methods for major pests and diseases; Recording ofobservations	1
15.	Correlating the observations using marker data – Gene pyramidingmethodsandtheirimplications	1
16.	Classificationofabioticstresses-Stressinducingfactors,moisturestress/droughtandwaterloggingandsubmergence	1
17.	Acidity,salinity/alkalinity/sodicity stress	1
18.	High/low temperature,wind stressetc.	1
19.	Stress due to soil factors and mineraltoxicity	1
20.	Physiological and Phenological responses	1
21.	Emphasis of abiotic stresses in developingbreedingmethodologies	1
22.	Geneticsofabioticstressresistance	1
23.	Genesandgenomicsinbreedingcultivarssuitable to low water regimes and water logging and submergence, high and low/freezing temperatures	1
24.	Utilizing MAS procedures for identifying resistant types inimportant crops like rice, sorghum, wheat, cotton, etc.	1
25.	Breeding for resistance tostresses caused by toxicity, deficiency and pollutants/ contaminants in soil, waterandenvironment	1
26.	Use of crop wild relatives as a source of resistance to biotic and abiotic factors inmajor field crops	1
27.	Transgenics in management of biotic and abiotic stresses,	1
28.	Use oftoxins for diseases and insect pestmanagement	1
29.	Protease inhibitors, for diseases and insect pestmanagement	1
30.	Lectins for diseases and insect pestmanagement	1
31.	Chitinases for diseases and insect pestmanagement	1
32.	Bt for diseases and insect pestmanagement	1
Total		**32**

Practical

Understandingtheclimatologicalparametersandpredisposalofbioticandabioticstressfactors-waysofcombatingthemfordiseasescausedbyfungiandbacteria;Symptomsanddatarecording;useofMASprocedures;Phenotypicscreeningtechniquesforsuckingpestsandchewingpests–Traitstobeobservedatplantandinsectlevel;Phenotypicscreeningtechniquesfornematodesandborers;WaysofcombatingthemEvaluatingtheavailablepopulationslikeRIL,NIL,etc.forpestresistance;UseofstandardMASprocedures.Breedingstrategies-Weeds–ecological,environmentalimpactsonthecrops;Breedingforherbicideresistance;Screeningcropsfordroughtandfloodresistance;factorstobeconsideredandbreedingstrategies;

Screeningvarietiesofmajorcropsforacidityandalkalinity-theireffectsandbreedingstrategies; Screeningforagecropsforresistancetosewagewaterandtanneryeffluents;Qualityparametersevaluation.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Understandingtheclimatologicalparametersandpredisposalofbioticandabioticstressfactors-waysofcombatingthemfordiseasescausedbyfungi	1
2.	Understandingtheclimatologicalparametersandpredisposalofbioticandabioticstressfactors-waysofcombatingthemfordiseasescausedbybacteria	1
3.	Symptomsanddatarecording	1
4.	UseofMASprocedures	1
5.	Phenotypicscreeningtechniquesforsuckingpests–Traitstobeobservedatplantandinsectlevel	1
6.	Phenotypicscreeningtechniquesforchewingpests–Traitstobeobservedatplantandinsectlevel	1
7.	Phenotypicscreeningtechniquesfornematodesandborers;Waysofcombatingthem	1
8.	EvaluatingtheavailablepopulationslikeRIL,NIL,etc.forpestresistance	1
9.	UseofMASprocedures	1
10.	Breedingstrategies-Weeds–ecological,environmentalimpactsonthecrops	1
11.	Breedingforherbicideresistance	1
12.	Screeningcropsfordroughtresistance;factorstobeconsideredandbreedingstrategies	1
13.	Screeningcropsforfloodresistance;factorstobeconsideredandbreedingstrategies	1
14.	Screeningvarietiesofmajorcropsforacidityandalkalinity-theireffectsandbreedingstrategies	1
15.	Screeningforagecropsforresistancetosewagewaterandtanneryeffluents	1
16.	Qualityparametersevaluation	1
Total		**16**

Suggested Readings

1. *BlumA.1988.PlantBreedingforStressEnvironments.CRCPress.*
2. *ChristiansenMNandLewisCF.1982.BreedingPlantsforLessFavourableEnvironments.*
3. *WileyInternational.*
4. *Fritz RS and Simms EL. (Eds.). 1992. Plant Resistance to Herbivores and Pathogens: Ecology,EvolutionandGenetics.TheUniversityofChicagoPress.*
5. *LiPHandSakaiA.1987.PlantColdHardiness.Liss,NewYorkSpringer*
6. *Luginpill P. 1969. Developing Resistant Plants - The Ideal Method of Controlling Insects. USDA,ARS,WashingtonDC.*

7. *MaxwellFGandJenningsPR.(Eds.).1980.BreedingPlantsResistanttoInsects.JohnWiley &Sons.Wiley-Blackwell.*
8. *RobertoF.2018.PlantBreedingforBioticandAbioticStressTolerance.Springer.*
9. *Russel GE. 1978. Plant Breeding for Pest and Disease Resistance. Butterworths.*
10. *SakaiAandLarcherW.1987.FrostSurvivalinPlants.Springer-Verlag.*
11. *TurenerNCandKramerPJ.1980.AdaptationofPlantstoWaterandHighTemperatureStress.*
12. *JohnWiley&Sons.*
13. *vanderPlankJE.1982.Host-PathogenInteractionsinPlantDisease.AcademicPress*

GPB 531 MOLECULAR BREEDING AND BIOINFORMATICS 3 (2+1)

Objectives

To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding.

Theory

Genotyping;BiochemicalandMolecularmarkers;Morphological,biochemicalandDNA-basedmarkers(RFLP,RAPD,AFLP,SSR,SNPs,ESTs,etc.),Functionalmarkers;Mappingpopulations(F_2s,backcrosses,RILs,NILsandDH);Molecularmappingandtaggingofagronomicallyimportant traits;Statisticaltoolsinmarkeranalysis.Allelemining;Marker-assistedselectionforqualitativeandquantitative traits;QTLsanalysisincropplants;Marker-assistedbackcrossbreedingforrapidintrogression; Genomics- assisted breeding;Generation of EDVs; Genepyramiding.IntroductiontoComparativeGenomics;Largescalegenomesequencingstrategies;Humangenomeproject;Arabidopsisgenomeproject;Ricegenomeproject;Comparativegenomicstools;Introductiontoproteomics;2Dgelelectrophoresis;chromatographyandsequencingbyEdmandegradationandmassspectrometry;Endopeptidases;Nanotechnologyanditsapplicationsincropimprovement.Recombinant DNA technology, transgenes, method of transformation, selectablemarkersandcleantransformationtechniques,vector-mediatedgenetransfer,physical methods of gene transfer; Production of transgenic plants in various fieldcrops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc. and commercialreleases; Biotechnology applications in male sterility/ hybrid breeding, molecularfarming;ApplicationofTissueculture inmolecularbreeding;MOsandrelatedissues (risk and regulations); GMO; International regulations, biosafety issues ofGMOs; Regulatory procedures in major countries including India, ethical, legal andsocialissues;Intellectualpropertyrights;Introductiontobioinformatics:bioinformatics tools, biological data bases (primary and secondary), implications incropimprovement.

Lecture Schedule -Theory

S. No.	Topics	No. of Lectures
1.	Genotyping;BiochemicalandMolecularmarkers;	1
2.	Morphological,biochemicalandDNA-basedmarkers(RFLP,RAPD,AFLP,SSR,SNPs,ESTs,etc.),	1
3.	Functionalmarkers	1

4.	Mappingpopulations(F_2s,backcrosses,RILs,NILsandDH)	1
5.	Molecularmappingandtaggingofagronomicallyimportanttraits	1
6.	Statisticaltoolsinmarkeranalysis	1
7.	Allelemining	1
8.	Marker-assistedselectionforqualitativeandquantitative traits	1
9.	QTLsanalysisincropplants	1
10.	Marker-assistedbackcrossbreedingforrapidintrogression	1
11.	Genomics- assisted breeding	1
12.	Generation of EDVs; Genepyramiding	1
13.	IntroductiontoComparativeGenomics	1
14.	Largescalegenomesequencingstrategies	1
15.	Humangenomeproject	1
16.	Arabidopsisgenomeproject	1
17.	Ricegenomeproject	1
18.	Comparativegenomicstools	1
19.	Introductiontoproteomics	1
20.	2Dgelelectrophoresis	1
21.	ChromatographyandsequencingbyEdmandegradationandmassspectrometry	1
22.	Endopeptidases	1
23.	Nanotechnologyanditsapplicationsincropimprovement	1
24.	Recombinant-DNA technology, transgenes, method of transformation, selectablemarkersandcleantransformationtechniques	1
25.	Vector-mediatedgenetransfer,physical methods of gene transfer;	1
26.	Production of transgenic plants in various fieldcrops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc and commercialreleases	1
27.	Biotechnology applications in male sterility/ hybrid breeding, molecularfarming	1
28.	ApplicationofTissueculture inmolecularbreeding	1
29.	MOsandrelatedissues (risk and regulations)	1
30.	GMO; International regulations, biosafety issues ofGMOs	1
31.	Regulatory procedures in major countries including India, ethical, legal andsocialissues;Intellectualpropertyrights	1
32.	Introductiontobioinformatics:bioinformatics tools, biological data bases (primary and secondary), implications incropimprovement	1
Total		**32**

Practical

Requirementsforplanttissueculturelaboratory;Techniquesinplanttissueculture;Mediacomponentsandmediapreparation;Asepticmanipulationofvariousexplants,observationsonthecontaminantsoccurringinmedia,interpretations;Inoculationofexplants,callusinductionandplantregeneration;Standardizingtheprotocolsforregeneration;Hardeningofregeneratedplants;Establishingagreenhouseandhardeningprocedures;Visittocommercialmicropropagationunit;Transformation usingAgrobacteriumstrains;GUSassayintransformedcells/tissues;DNAisolation,DNApurity andquantificationtests;Gelelectrophoresisofproteinsandisozymes,PCR-basedDNAmarkers,gelscoringanddataanalysisfortaggingandphylogeneticrelationship;Construction ofgeneticlinkagemapsusingcomputersoftware;NCBIGenomicResources,GBFF,SwissProt,Blastn/Blastp,GenePredictionTool,ExpasyResources,PUBMEDandPMC,OMIMandO

MIA,ORFfinder;ComparativeGenomicResources:-
MapViewer(UCSCBrowserandEnsembl);Primerdesigning-Primer3/PrimerBLAST.

Lecture Schedule -Practical

S. No.	Topics	No. of Lectures
1.	Requirementsforplanttissueculturelaboratory, Techniques in plant tissue culture	1
2.	Techniquesinplanttissueculture	1
3.	Mediacomponentsandmediapreparation	1
4.	Septicmanipulationofvariousexplants,observationsonthecontaminantsoccurringinmedia,interpretations	1
5.	Standardizingtheprotocolsforregeneration	1
6.	Hardeningofregeneratedplants, Establishingagreenhouseandhardeningprocedures	1
7.	Visittocommercialmicropropagationunit	1
8.	TransformationusingAgrobacteriumstrains	1
9.	GUSassayintransformedcells/tissues	1
10.	DNAisolation,DNApurityandquantificationtests	2
11.	Gelelectrophoresisofproteinsandisozymes,PCR-basedDNAmarkers,gelscoringanddataanalysisfortaggingandphylogeneticrelationship	2
12.	Constructionofgeneticlinkagemapsusingcomputersoftware	1
13.	NCBIGenomicResources,GBFF,SwissProt,Blastn/Blastp,GenePredictionTool,ExpasyResources,PUBMEDandPMC,OMIMandOMIA,ORFfinder	1
14.	ComparativeGenomicResources:-MapViewer(UCSCBrowserandEnsembl); Primerdesigning-Primer3/PrimerBLAST.	1
Total		**16**

Suggested Readings

1. *Azuaje Fand DopazoJ. 2005.DataAnalysis andVisualizationin Genomicsand Proteomics.JohnWileyandSons.*
2. *Brown TA. 1991. Essential Molecular Biology: a practical Approach. Oxford university press,2002,2nd edition*
3. *ChawalaHS.2000. Introductionto PlantBiotechnology. Oxford& IBHPublishing Co.Pvt.Ltd.*
4. *ChopraVLandNasimA.1990.GeneticEngineeringandBiotechnology:Concepts,MethodsandApplications.Oxford&IBH.*
5. *GuptaPK.1997.ElementsofBiotechnology.RastogiPubl.*
6. *HackettPB,FuchsJAandMessingJW.1988.AnIntroductiontoRecombinantDNATechnology-BasicExperimentsinGeneManipulation.2ndEd.BenjaminPubl.Co.*
7. *JollèsPandJörnvallH.2000.ProteomicsinFunctionalGenomics:ProteinStructureAnalysis .*
8. *Birkhäuser.*
9. *LewinB.2017.GenesXII.Jones&Bartlettlearning,2017.*

10. *RobertNTandDennisJG.2010.PlantTissueCulture,Development,andBiotechnology.CRC Press.*
11. *SambrookJandRusselD.2001.MolecularCloning-aLaboratoryManual.3rdEd.ColdSpringHarborLab.Press.*
12. *SinghBD.2005.Biotechnology,ExpandingHorizons.KalyaniPublishers,NewDelhi.*
13. *WatsonJ.2006.RecombinantDNA.ColdSpringharborlaboratorypress.*

Ph.D.Programme

GPB 611 ADVANCES IN PLANT BREEDING SYSTEMS 3 (3+0)

Objective

To impart theoretical knowledge about advances in plant breeding

Theory

Advances in reproductive biology of crops; Genes governing the whorls formationand various models proposed; Pollen pistil interaction, biochemical and molecularbasis,environmentalfactorsgoverninganthesisandbottlenecksforgenetransfer.Plant Breeding methodologies: Classic versus modern; Over view of Pre and PostMendelianbreedingmethodsinselfandcrosspollinatedcrops;Molecularandtransgenic breeding approaches; doubled haploid breeding, shuttle breeding, forwardand reverse breeding, speed breeding, participatory plant breeding, breeding fororganicsituations.Principles and procedures in the formation of a complex population, Genetic basis ofpopulation improvement in crop plants; Recurrent selection methods in self and crosspollinatedcropsandtheirmodifications;Convergentselection,divergentselection;Recurrentselection,usefulnessinhybridbreedingprograms;Reciprocalrecurrentselection;Selectioninclonallypropagatedcrops–Assumptionsandrealities.Choice of molecular markers for plant breeding efficiency, fingerprinting and geneticdiversity assessment, application of MAS for selection of qualitative and quantitativetraits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exoticgermplasm,introgressionlibraries.Geneticresources:primary,secondary,tertiaryandalien transgenepool;Molecularand biochemical basis of self-incompatibility and male sterility, nucleocytoplasmicinteractionswithspecialreferencetomalesterility–genetic,biochemicalandmolecularbases.Genetic engineering technologies to create male sterility, prospects and problems,use of self-incompatibility and sterility in plant breeding-case studies; Fertilityrestorationinmalesterilelinesandrestorerdiversificationprograms;Conversionofagronomically ideal genotypes into male sterile: Concepts and breeding strategies;Case studies-Generating new cyto-nuclear interaction system for diversification ofmale sterile; Stability of male sterile lines-Environmental influence on sterility,Environmentally Induced Genic Male Sterility (EGMS)-Types of EGMS; Influenceontheirexpression,geneticstudies;Photoandthermosensitivegeneticmalesterilityand its use in heterosis breeding; Temperature sensitive genetic male sterility andits use heterosis breeding; Apomixis and its use in heterosis breeding;

Incongruity:FactorsinfluencingincongruityMethodstoovercomeincongruitymechanisms.Breedingforclimatechange-
Improvingrootsystems,abioticstresstolerance,wateruseefficiency,floodingandsub-mergencetolerance;Bioticstresstolerance;Nutrientuseefficiency,nitrogenfixationandassimilation,greenhousegasesandcarbonsequestration;Breedingforbio-fortification.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Advances in reproductive biology of crops	1
2.	Genes governing the whorls formationand various models proposed	1
3.	Pollen pistil interaction: biochemical and molecularbasis	1
4.	Environmentalfactorsgoverninganthesisandbottlenecksforgenetransfer	2
5.	Plant Breeding methodologies: Classic versus modern	2
6.	Over view of Pre and PostMendelianbreedingmethodsinselfandcrosspollinatedcrops	2
7.	Molecularbreeding approaches	2
8.	Transgenic breeding approaches	1
9.	Doubled haploid breeding shuttle breeding, forwardand reverse breeding, speed breeding, participatory plant breeding, breeding fororganicsituations	2
10.	Principles and procedures in the formation of a complex population	1
11.	Genetic basis ofpopulation improvement in crop plants	2
12.	Recurrent selection methods in self and crosspollinatedcropsandtheirmodifications	2
13.	Convergentselection,divergentselection	1
14.	Recurrentselection,usefulnessinhybridbreedingprograms	2
15.	Reciprocalrecurrentselection;Selectioninclonallypropagatedcrops–Assumptionsandrealities	2
16.	Choice of molecular markers for plant breeding efficiency, fingerprinting and geneticdiversity assessment, application of MAS for selection of qualitative and quantitativetraits	2
17.	Gene pyramiding, accelerated backcrossing, marker-based utilization of exoticgermplasm,introgressionlibraries	2
18.	Geneticresources:primary,secondary,tertiaryandalientransgenepool	1
19.	Molecularand biochemical basis of self-incompatibility and male sterility, nucleocytoplasmicinteractionswithspecialreferencetomalesterility–genetic,biochemicalandmolecularbases	2
20.	Genetic engineering technologies to create male sterility, prospects and problems,use of self-incompatibility and sterility in plant breeding – case studies	2
21.	Fertilityrestorationinmalesterilelinesandrestorerdiversificationprograms	1
22.	Conversionofagronomically ideal genotypes into male sterile: Concepts and breeding strategies	2
23.	Case studies - Generating new cyto-nuclear interaction system	2

	for diversification ofmale sterile	
24.	Stability of male sterile lines – Environmental influence on sterility,Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influenceontheirexpression,geneticstudies	2
25.	Photoandthermosensitivegeneticmalesterilityand its use in heterosis breeding	1
26.	Temperature sensitive genetic male sterility andits use heterosis breeding	1
27.	Apomixis and its use in heterosis breeding	1
28.	Incongruity:FactorsinfluencingincongruityMethodstoovercomein congruitymechanisms.	1
29.	Breedingforclimatechange-Improvingrootsystems,abioticstresstolerance,wateruseefficiency, floodingandsub-mergencetolerance	1
30.	Bioticstresstolerance	1
31.	Nutrientuseefficiency,nitrogenfixationandassimilation,greenhousegasesandcarbonsequestration	1
32.	Breedingforbio-fortification.	1
Total		**48**

Suggested Readings

1. *AgarwalRL.1996. FundamentalsofPlantBreedingandHybridSeedProduction.Oxford&IBH.*
2. *AllardRW.1966.PrinciplesofPlantBreeding.JohnWiley&Sons.*
3. *BriggsFNandKnowlesPF.1967.IntroductiontoPlantBreeding.Reinhold.*
4. *FehrWR.1987.PrinciplesofCultivarDevelopment:TheoryandTechnique.VolI.Macmillan.HayesHK,ImmerFRandSmithDC.1955.MethodsofPlantBreeding.McGraw-Hill.*
5. *KangMSandPriyadarshanPM(Edit.).2007.BreedingMajorFoodStaples.BlackwellPublishing.*
6. *KoleC.2013.GenomicsandBreedingforClimate-ResilientCrops.Springer.Volume2-TargetTraits.*
7. *MandalAK,GanguliPKandBanerjiSP.1995.AdvancesinPlantBreeding.Vol.I,II.CBS. RichardsAJ.1986.PlantBreedingSystems.GeorgeAllen&Unwin.*
8. *SharmaJR.1994.PrinciplesandPracticeofPlantBreeding.TataMcGraw-Hill.*
9. *SimmondsNW.1979.PrinciplesofCropImprovement.Longman.*
10. *SinghBD.1997.PlantBreeding:PrinciplesandMethods.5thEd.,KalyaniPublishers,NewDelhi.*
11. *SinghP.1996.EssentialsofPlantBreeding.KalyaniPublishers,NewDelhi.WelshJR.1981. FundamentalsofPlantGeneticandBreeding.JohnWiley.*

GPB 612 IPR AND REGULATORY MECHANISM (E-COURSE*)1 (1+0)

Objectives

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR), related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge- based economy.

Theory

HistoricalperspectivesandneedfortheintroductionofIntellectualPropertyRightregime;TRIPSandvariousprovisionsinTRIPSAgreement;IntellectualPropertyandIntellectualPropertyRights(IPRs),benefitsofsecuringIPRs;IndianLegislationsfortheprotectionofvarioustypesofIntellectualProperties;Fundamentalsofpatents,copyrights,geographicalindications,designsandlayout,tradesecretsandtraditionalknowledge,trademarks,protectionofplantvarietiesandfarmers'rightsand biodiversity protection; Protectable subject matters, protection in biotechnology,protection of other biological materials, ownership and period of protection; NationalBiodiversity protection initiatives; Convention on Biological Diversity; InternationalTreatyonPlantGeneticResourcesforFoodandAgriculture;Licensingoftechnologies, Materialtransferagreements,ResearchcollaborationAgreement,LicenseAgreement.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	HistoricalperspectivesandneedfortheintroductionofIntellectualPropertyRightregime	1
2.	TRIPSandvariousprovisionsinTRIPSAgreement	1
3.	IntellectualPropertyandIntellectualPropertyRights(IPR),	1
4.	BenefitsofsecuringIPRs	1
5.	Indianlegislationsfortheprotectionofvarioustypesofintellectualproperties	1
6.	Fundamentalsofpatents,	1
7.	Copyrights,	1
8.	Geographicalindications	1
9.	Designsandlayout,tradesecrets	1
10.	Traditionalknowledgeandtrademarks	1
11.	Protectionofplantvarietiesandfarmers'rightsand biodiversity protection	1
12.	Protectable subject matters, protection in biotechnology,	1
13.	Protection of other biological materials, ownership and period of protection	1
14.	Nationalbiodiversity protection initiatives; Convention on Biological Diversity	1
15.	InternationalTreatyonPlantGeneticResourcesforFoodandAgriculture	1
16.	Licensingoftechnologies,materialtransferagreements,researchcollaborationagreement,licenseagreement	1
Total		**16**

Suggested Readings

1. *ErbischFHandMarediaK.1998.IntellectualPropertyRightsinAgriculturalBiotechnology, CABI.*
2. *GanguliP.2001.IntellectualPropertyRights:UnleashingKnowledgeEconomy.McGraw-Hill.*

3. *IntellectualPropertyRights:KeytoNewWealthGeneration.2001.NRDC&AestheticTechnologies.*
4. *MinistryofAgriculture,GovernmentofIndia.2004.StateofIndianFarmer.Vol.V.TechnologyGenerationandIPRIssues.AcademicFoundation.*

GPB 613 Plant Genetic Resources, Conservation and Utilization 2 (2+0)

Objective

To impart knowledge on the methods of germplasm conservation and its utilization

Theory

Conceptofnaturalreservesandnaturalgenebanks;*Insitu*conservationofwildspeciesinnaturereserves:*insitu*conservationcomponents,factorsinfluencingconservationvalue,nationalplanfor*insitu*conservation;*insitu*conservationofagro-biodiversityon-farm;scientificbasisof*insitu*conservationon-farm,buildingon-farmconservationinitiatives,implementationofon-farmconservation,managementofinsituconservedgeneticdiversityon-farm,enhancingbenefitsforfarmersfromlocalcropdiversity.*Ex situ* conservation: components, plant genetic resources conservation in gene banks,national gene banks, gene repositories, preservation of genetic materials under naturalconditions,permafrostconservation,guidelinesforseedmultiplicationandexchangetonetworkofactive/workingcollections,orthodox,recalcitrantseeds-differencesinhandling,clonalrepositories,geneticstabilityunderlongtermstoragecondition.*In-vitro* storage, maintenance of *in-vitro* culture under different conditions, *in-vitro*bankmaintenancefortemperateandtropicalfruitcropspecies,spices,tubers,bulbouscrops,medicinalandendangeredplantspecies,conservationofembryosand ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture,micropropagationtechniques,problems,prospectsof*in-vitro*genebank.Cryopreservation-procedureforhandlingseedsoforthodoxandrecalcitrant cryo-protectants,desiccation,rapidfreezing,slowfreezing,vitrificationtechniques,encapsulation/dehydrationtechniques,nationalfacilities,achievements,applicationofcryopreservationinagricultural,horticulturalandforestrycrops.Problemsandprospects;challengesahead.

ConceptandprocedureforPGRmanagement,germplasmcharacterization,evaluationandutilization;Conceptofcoreandminicore;collectionsandregistrationofplantgermplasm.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Conceptofnaturalreservesandnaturalgenebanks	1
2.	*In-situ*conservationofwildspeciesinnaturereserves:*in-situ*conservationcomponents	1
3.	Factorsinfluencingconservationvalue,nationalplanfor*in-situ*conservation	2
4.	*In-situconservation*ofagro-biodiversityon-farm	1
5.	Scientificbasisof*insitu*conservationon-farm,buildingon-farmconservationinitiatives,implementationofon-	2

	farmconservation	
6.	Managementof*insitu*conservedgeneticdiversityon-farm,enhancingbenefitsforfarmersfromlocalcropdiversity	1
7.	*Ex-situ* conservation: components, plant genetic resources conservation in gene banks,national gene banks, gene repositories, preservation of genetic materials under naturalconditions	2
8.	Permafrostconservation,guidelinesforseedmultiplicationandexchangetonetworkofactive/workingcollections	2
9.	Orthodox,recalcitrantseeds-differencesinhandling	1
10.	Clonalrepositories,geneticstabilityunderlongtermstorageconditi on	1
11.	*In-vitro* storage, maintenance of *in-vitro* culture under different conditions	2
12.	*In-vitro*bankmaintenancefortemperateandtropicalfruitcropspecies,spices,tubers,bulbouscrops,medicinalandendangeredplantspecies	2
13.	Conservationofembryosand ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture,micropropagationtechniques,problems,prospectsofin-vitrogenebank.	2
14.	Cryopreservationprocedureforhandlingseedsoforthodoxandrecalcitrant cryo-protectants,desiccation,rapidfreezing,slowfreezing	2
15.	Vitrificationtechniques,encapsulation/dehydrationtechniques	1
16.	Nationalfacilities,achievements	1
17.	Applicationofcryopreservationinagricultural,horticulturalandforestrycrops.Problemsandprospects;challengesahead	2
18.	ConceptandprocedureforPGRmanagement,	2
19.	Germplasmcharacterization,evaluationandutilization	2
20.	Conceptofcoreandminicore;collectionsandregistrationofplantgermplasm	2
Total		**32**

Suggested Readings

1. *EllisRH,RobertsEHandWhiteHeadJ.1980.ANewMoreEconomicandAccurateApproachto Monitor the Viability of Accessions During Storage in Seed Banks. FAO/ IBPGR Pl.Genet.ResourcesNews41-3-18.*
2. *Frankel OH and Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. CambridgeUniversityPress,Cambridge.*
3. *Paroda RS and Arora RK.1991. Plant Genetic resource Conservation and management, NBPGR,New-Delhi.*
4. *SimmondsNW.1979.PrinciplesofCropImprovement,Longman.*
5. *Westwood MN. 1986. Operation Manual for National Clonal Germplasm Repository. ProcessedReport.USDA-ARSandOregonStateUniv.Oregon,USA.*
6. *Withers LA. 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR,Rome,Italy.*

GPB 614 MOLECULAR CYTOGENETICS FOR CROP IMPROVEMENT2 (2+0)

Objective

This course focuses on applications of cytogenetic techniques for crop improvement

Theory

Organization and structure of genome, Genome size, Organization of organellargenomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactionsandsignaltransduction;InheritanceandexpressionoforganellarDNA;Variationin DNA content, C-value paradox; Sequence complexity – Introns and Exons,Repetitivesequences,Roleofrepetitivesequence.Karyotyping:Chromosomebandingand chromosomepainting;TrackingintrogressionsusingFISH,GISH,localizationandmappingofgenes/genomicsegments.Pre-breedingandapplicationsofcytogeneticalmethodsforcropimprovement;Location and mapping of genes on chromosomes: deficiency method; Interchangegenetic consequence, identification of chromosomes involved and gene location;balancedlethalsystems,theirmaintenanceandutility;Multipleinterchanges-useinproducinginbreds,transferofgenes-linkedmarkermethods;Duplication-production and use; Inversions and location of genes; B/A chromosome translocationsandgenelocation.Trisomics- types, production, breeding behavior and location of genes, use of balancedtertiary trisomics in hybrid seed production; Monosomics methods of production,breeding behavior and location of genes; Intervarietal substitutions-allelic and non-allelicinteractions;Telocentricmethodofmapping.Cytogenomics:Concept,toolsandtechniquesforcropimprovement;Chromosomesorting:Isolationofspecificchromosomefordevelopmentofmolecularmapsandgenelocation.Role of polyploidy in crop evolution and breeding. Auto and allopolyploids;

Distanthybridization,barrierstointerspecificandintergenerichybridization;Behaviourofinterspecificandintergenericcrosses.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Organization and structure of genome	2
2.	Genome size, Organization of organellargenomes	1
3.	Nuclear DNA organization	1
4.	Nuclear and cytoplasmic genome interactionsandsignaltransduction	1
5.	InheritanceandexpressionoforganellarDNA	1
6.	Variationin DNA content, C-value paradox	1
7.	Sequence complexity : Introns and Exons	1
8.	Repetitivesequences,Roleofrepetitivesequence	1
9.	Karyotyping–Chromosomebanding	1
10.	Chromosomepainting	1
11.	TrackingintrogressionsusingFISH,GISH,	1
12.	Localizationandmappingofgenes/genomicsegments	1
13.	Applicationsofcytogeneticalmethodsforcropimprovement	2

14.	Location and mapping of genes on chromosomes: deficiency method	1
15.	Interchangegenetic consequence, identification of chromosomes involved and gene location	1
16.	Balancedlethalsystems,theirmaintenanceandutility	1
17.	Multipleinterchanges: useinproducinginbreds,transferofgenes-linkedmarkermethods	1
18.	Duplication-production and use	1
19.	Inversions and location of genes	1
20.	B/A chromosome translocationsandgenelocation	1
21.	Trisomics: types, production, breeding behavior and location of genes, use of balancedtertiary trisomics in hybrid seed production	1
22.	Monosomics methods of production,breeding behavior and location of genes;	1
23.	Intervarietal substitutions-allelic and non-allelicinteractions	1
24.	Telocentricmethodofmapping	1
25.	Cytogenomics:Concept,toolsandtechniquesforcropimprovement	2
26.	Chromosomesorting:Isolationofspecificchromosomefordevelopment ofmolecularmapsandgenelocation	1
27.	Role of polyploidy in crop evolution and breeding	1
28.	Auto and allopolyploids	1
29.	Distanthybridization,barrierstointerspecificandintergenerichybridization	1
30.	Behaviourofinterspecificandintergenericcrosses	1
Total		**32**

Suggested Readings

1. *ClarkMSandWallWJ.1996.Chromosomes:TheComplexCode.Chapman&Hall.30June1996*
2. *CongerBV.(Ed.).1981.CloningAgriculturalPlantsviain-vitroTechniques.CRCPress.31January2018*
3. *ConstabelFandVasilIK.(Eds.).1988.CellCultureandSomaticCellGeneticsofPlants.Vol.*
4. *V.CellCultureandPhytochemicalsinPlantCellCultures.AcademicPress.GuptaPK.2006.Cytogenetics.RastogiPublisher*
5. *LalRandLalS.(Eds.).1990.CropImprovementUtilizingBiotechnology.CRCPress.MantelSHandSmithH.1983.PlantBiotechnology.CambridgeUniversityPress.*
6. *SenSKandGilesKL.(Eds.).1983.PlantCellCultureinCropImprovement.PlenumPress.13July2013*
7. *Yao-ShanF.2002.MolecularCytogenetics:ProtocolsandApplication.HumanPress.*

GPB 621 GENOMICS IN PLANT BREEDING3 (3+0)

Objectives

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

Theory

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes;Conceptofgenomesizeandcomplexity:C-valueparadox,repetitiveanduniqueDNA.Genomesequencing:Principlesandtechniquesofconventionalapproachesandnextgenerationsequencingincludingsequencing-by-synthesis/ligationandsinglemoleculerealtime(SMRT)technologies;Applicationsofsequenceinformation:structural,functionalandcomparativegenomics;Plantgenomeprojects:Strategiesforgenomesequencingincludingshotgunandclone-by-clonemethod.Molecular maps: Use of molecular markers/ SNPs for development of genetic andphysical maps; Linkage and LD-based gene mapping approaches including gene/QTL mapping, genome wide association studies (GWAS) and association analysis;Integration of genetic and physical map for map-based cloning of economicallyimportantgenes.Conceptofallelemining;Diversityarraytechnology:conceptsandapplications.Functional genomics: concept of reverse and forward genetics; Use of activationtagging,transposontagging,insertionalmutagenesis,TILLINGandeco-TILLINGforcropimprovement;Genome-wideandgene-specifictranscriptomicsapproaches:serial analysis of gene expression, massively parallel signature sequencing, nextgeneration sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR andmolecularbeacon.Developmentandmanagementofdatabase;Applicationsofbioinformaticstools/softwareingenomicsforcropimprovement.Basicconceptsofhigh-throughputproteomics,metabolomicsandphenomics.Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENSand ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sistersforCropImprovement;Genomics-basedplantbreeding:Genome-WideGeneticDiversity Studies, Identification of molecular markers linked to single Genes andQTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Associationmapping,BreedingbyDesign,Genomeselection)**.**

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes	2
2.	Conceptofgenomesizeandcomplexity:C-valueparadox,repetitiveandunique DNA	2
3.	Genomesequencing:Principlesandtechniquesofconventionalapproachesandnextgenerationsequencingincludingsequencing-by-synthesis/ligationandsinglemoleculerealtime(SMRT)technologies	2
4.	Applicationsofsequenceinformation:structural,functionalandcomparativegenomics	2
5.	Plantgenomeprojects:Strategiesforgenomesequencingincludingshotgunandclone-by-clonemethod	2
6.	Molecular maps: Use of molecular markers/ SNPs for development of genetic andphysical maps	2
7.	Linkage and LD-based gene mapping approaches including	2

	gene/QTL mapping,	
8	Genome wide association studies (GWAS) and association analysis	1
9.	Integration of genetic and physical map for map-based cloning of economicallyimportantgenes	2
10.	Conceptofallelemining	2
11.	Diversityarraytechnology:conceptsandapplications	2
12.	Functional genomics: concept of reverse and forward genetics	2
13.	Use of activationtagging,transposontagging,insertionalmutagenesis,	2
14.	TILLINGandeco-TILLINGforcropimprovement	1
15.	Genome-wideandgene-specifictranscriptomicsapproaches:serial analysis of gene expression,	2
16.	Massively parallel signature sequencing, nextgeneration sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR andmolecularbeacon	2
17.	Developmentandmanagementofdatabase	2
18.	Applicationsofbioinformaticstools/softwareingenomicsforcropimprovement	2
19.	Basicconceptsofhigh-throughputproteomics,metabolomicsandphenomics	2
20.	Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENSand ZFNs for crop improvement	3
21.	Cisgenesis and Intragenesis tools as twin sistersforCropImprovement	2
22.	Genomics-basedplantbreeding:Genome-WideGeneticDiversity Studies,	2
23.	Identification of molecular markers linked to single Genes andQTL,	2
24.	Marker Assisted Selection (Marker Assisted Backcross Selection),	1
25.	Associationmapping,BreedingbyDesign,Genomeselection	2
Total		**48**

Suggested Readings

1. *Alonso JM, Stepanova AN. 2015. Plant Functional Genomics: Methods and Protocols. Springer.ChopraVL,SharmaRP,BhatSRandPrasannaBM.2007. SearchforNewGenes.Academic Foundation,NewDelhi.*
2. *HackettPB,FuchsJAandMessingJW.1988.AnIntroductiontoRecombinantDNATechnology—BasicExperimentsinGeneandManipulation.2nd Ed.BenjaminPublicationCo.*
3. *PrimoseSBandTwymanRM.2006.PrinciplesofGeneManipulationandGenomics.7thEd.Wiley-BlackwellPublishing.*
4. *Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold SpringHarborLaboratoryPress.*
5. *SinghBD.2005.Biotechnology:ExpandingHorizons.KalyaniPublishers,NewDelhi.SomersDJ,LangridgeP,GustafsonJP.2009.PlantGenomics:MethodsandProtocols.Springer.*

GPB 622 ADVANCES IN BIOMETRICAL GENETICS 3 (2+1)

Objectives

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

Theory

Continuous variation-evolutionary studies; Genetic principles of continuous variation,Qualitativeandquantitativetechniques-differences,populationtypes,approaches;various types of metrices, F_2, $F_3$and mixed; Selection of parents Simultaneousselectionmodels;UseofMultipleregressionanalysisinselectionofgenotypes.Components of mean- Additive effect, breeding value, coefficient of gene dispersion,dominance;Simplescalingtest,expectationofmeanofcharacterinvarioustypesoffamiliesincouplinganddispersedphase;Epistasis-Specification,weightedandunweightedjointscalingtest;Effectoflinkagetogenerationmean,specificationofmeantoG×Einteraction.Componentofvariances-advantages,variancesofdifferentgenerations,balancesheet of variance; estimation of parameters-weighted and unweighted, least squareanalysis; random mating population; experimental population-BIPs, NCD-I, II, III,Triple test cross for random mating population and inbreds; Estimates of linkageandnon-allelicinteractions;Combiningabilityanalysis,Hayman'sApproach,G × E Interaction, stability and adaptability; Advanced models in stability analysis -Patternanalysis-AdditiveMainEffectandMultiplicativeInteraction(AMMI)analysisandotherrelatedmodels;Meritsandlimitationofdifferentstabilityanalysismethods; Analysis and selection of genotypes; Methods and steps to select the bestmodel-Biplotsandmappinggenotypes.Construction of saturated linkage maps, concept of framework map development;QTLs-different types of markers and mapping populations, linkage maps, mapping-StrategiesforQTLmapping-desiredpopulations,statisticalmethods;MAGICpopulations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plantbreeding-selectionbasedonmarkers-simultaneousselectionbasedonmarkerand phenotype - Factors influencing MAS; Heritability of the trait, proportion ofgenetic variance, linkage disequilibrium between markers and traits and selectionmethods;Useofadvancedsoftwarepackagesforbiometricalanalysis,interpretationofanalyseddata.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Continuous variation-evolutionary studies	1
2.	Genetic principles of continuous variation,Qualitativeandquantitativetechniques-differences,populationtypes,approaches	1
3.	Various types of metrices, F_2, $F_3$and mixed	1
4.	Selection of parents, Simultaneous selectionmodels	1
5.	UseofMultipleregressionanalysisinselectionofgenotypes	1

6.	Components of mean- Additive effect, breeding value, coefficient of gene dispersion,dominance	1
7.	Simplescalingtest,expectationofmeanofcharacterinvarioustypesoffamiliesincoupli nganddispersedphase	1
8.	Epistasis-Specification,weightedandun-weightedjointscalingtest	1
9.	Effectoflinkagetogenerationmean,specificationofmeantoG×Einteraction	1
10.	Componentofvariances-advantages,variancesofdifferentgenerations,balancesheet of variance	1
11.	estimation of parameters-weighted and unweighted, least squareanalysis	1
12.	random mating population; experimental population-BIPs, NCD-I, II, III,Triple test cross for random mating population and inbreds	3
13.	Estimates of linkageandnon-allelicinteractions	1
14.	Combiningabilityanalysis,Hayman'sApproach	2
15.	G × E Interaction, stability and adaptability; Advanced models in stability analysis -Patternanalysis-AdditiveMainEffectandMultiplicativeInteraction(AMMI)analysisandotherrelatedmodels	3
16.	Meritsandlimitationofdifferentstabilityanalysis	1
17.	Methods and steps to select the bestmodel-Biplotsandmappinggenotypes	1
18.	Construction of saturated linkage maps, concept of framework map development	2
19.	QTLs-different types of markers and mapping populations, linkage maps, mapping-StrategiesforQTLmapping-desiredpopulations,statisticalmethods	3
20.	MAGICpopulations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plantbreeding-selectionbasedonmarkers-simultaneousselectionbasedonmarkerand phenotype - Factors influencing MAS	2
21.	Heritability of the trait, proportion ofgenetic variance, linkage disequilibrium between markers and traits and selectionmethods	1
22.	Useofadvancedsoftwarepackagesforbiometricalanalysis,interpretationofanalyseddata	2
Total		**32**

Practical

Generationmeananalysis:ABCscalingtestandJointscalingtest-Analysisandinterpretation;Estimationofvarianceofdifferentfilialgenerationsandinterpretations;Diallelanalysis:Numerical,graphicalandcombiningabilityanalysis;Triallelanalysis;NCDesigns:Tripletestcrossanalysis;Stabilityanalysis:EberhartandRusselmodel;AMMImodel-PrincipalComponentAnalysismodel-Additiveandmultiplicativemodel - Shifted multiplicative model - Analysis and selection of genotypes - Methodsandstepstoselectthebestmodel-Selectionsystems-Biplotsandmappinggenotypes;Construction of linkage maps and QTL mapping - Strategies

for QTL mapping;statisticalmethodsinQTLmapping;PhenotypeandMarkerlinkagestudies;Useofadvancedsoftwareinbiometricalanalysis.

Lecture Schedule - Practical

S. No.	Topics	No. of Lectures
1.	Generationmeananalysis:ABCscalingtestandJointscalingtest-Analysisandinterpretation	2
2.	Estimationofvarianceofdifferentfilialgenerationsandinterpretations	1
3.	Diallelanalysis:Numerical,graphicalandcombiningabilityanalysis; Triallelanalysis	2
4.	NCDesigns:Tripletestcrossanalysis	1
5.	Stabilityanalysis:EberhartandRusselmodel	1
6.	AMMImodel-PrincipalComponentAnalysismodel-Additiveandmultiplicativemodel - Shifted multiplicative model - Analysis and selection of genotypes - Methodsandstepstoselectthebestmodel-Selectionsystems-Biplotsandmappinggenotypes	4
7.	Construction of linkage maps and QTL mapping - Strategies for QTL mapping	2
8.	StatisticalmethodsinQTLmapping	1
9.	PhenotypeandMarkerlinkagestudies	1
10.	Useofadvancedsoftwareinbiometricalanalysis	1
Total		**16**

Suggested Readings

1. *BosIandCaligariP.1995.SelectionMethodsinPlantBreeding.Chapman&Hall.*
2. *DabholkarAR.1993. ElementsofBiometricalGenetics.ConceptPublishingCo.NewDelhi.*
3. *FalconerDS and Mackay J. 1996.Introduction to Quantitative Genetics(4Ed.).ELBS/Longman, London.*
4. *MatherKandJinksJL.1985.BiometricalGenetics(3rdEd.).ChapmanandHall,London.*
5. *NandarajanNandGunasekaranM.2008.QuantitativeGeneticsandBiometricalTechniquesinPlantBreeding.KalyaniPublishers,NewDelhi.*
6. *RoyD.2000.PlantBreeding,AnalysisandExploitationofVariation.NarosaPublishingHouse,NewDelhi.*
7. *SinghPandNarayananSS.1993.BiometricalTechniquesinPlantBreeding.KalyaniPublishers,NewDelhi.*
8. *SinghRKandChoudharyBD.1987.BiometricalMethodsinQuantitativeGenetics.KalyaniPublishers,NewDelhi.*
9. *WeirDS.1990.GeneticDataAnalysis.MethodsforDiscretePopulationGeneticData.SinauerAssociates.*
10. *WrickeGandWeberWE.1986.QuantitativeGeneticsandSelectioninPlantBreeding.WalterdeGruyter.*

GPB 623 CROP EVOLUTION 3 (3+0)

Objectives

To impart knowledge on crop evolutionary aspects and role of mutations, hybridizations and polyploidy in crop evolution and improvement

Theory

Originandevolutionofspecies;Centresofdiversity/origin,diffusedcentres;Timeandplaceofdomestication;Patternsofevolutionanddomestication-examplesandCasestudies;Domesticationanduniformity-Characteristicsofearlydomesticationandchanges–Conceptofgenepoolsandcropevolution;SelectionandGeneticdrift–Consequences.Speciationanddomestication–Theprocessofspeciation,Reproductiveisolationbarriers;Geneticdifferentiationduringspeciation;Hybridization-speciationandextinction;Exploitationofnaturalvariation:Earlyattemptstoincreasevariation,Distanthybridizationandintrogression,Inter-specific,inter-generichybridization,scopeandlimitations,techniquestoovercomethelimitations;Genetransferintocultivatedspecies,toolsandtechniques;Validationoftransferredgenesandtheirexpression;Controlledintrogressions.Processesincropevolutionandstabilizationofpolyploids,cytogeneticandgeneticstabilization;Genomeorganization–Transgenesisincropevolution,Multifactorialgenome,Intragenomicinteraction,Intergenomicinteraction,Genomeintrogression;Methods to study crop evolution - Contemporary Methods, Based on morphologicalfeatures,Cytogeneticanalysis,Allozymevariationsandcropevolution,DNAmarkers,genome analysisand comparativegenomics.Evolutionarysignificanceofpolyploidy,evolutionofcropplantsthroughploidymanipulations;Polyploids:methods,useofautopolyploids;haploidyandDH-methodof production and use, allopolyploids; synthesis of new crops; Case studies – Cereals,Pulses,Oilseeds,vegetables,Fibrecrops,Plantationcrops,Foragecrops,Tubercrops,MedicinalPlants.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Originandevolutionofspecies	2
2.	Centresofdiversity/origin,diffusedcentres	2
3.	Timeandplaceofdomestication, Patternsofevolutionanddomestication-examplesandCasestudies	2
4.	Domesticationanduniformity– Characteristicsofearlydomesticationandchanges	2
5.	Conceptofgenepoolsandcropevolution	1
6.	SelectionandGeneticdrift–Consequences	2
7.	Speciationanddomestication– Theprocessofspeciation,Reproductiveisolationbarriers	2
8.	Geneticdifferentiationduringspeciation	2
9.	Hybridization-speciationandextinction	2
10.	Exploitationofnaturalvariation:Earlyattemptstoincreasevariation	2
11.	Distanthybridizationandintrogression,	2
12.	Inter-specific,inter-	2

	generichybridization,scopeandlimitations,techniquestoovercomethelimitations	
13.	Genetransferintocultivatedspecies,toolsandtechniques	2
14.	Validationoftransferredgenesandtheirexpression;controlledintrogressions	2
15.	Processesincropevolutionandstabilizationofpolyploids,cytogeneticandgeneticstabilization	2
16.	Genomeorganization–transgenesisincropevolution	2
17.	Multifactorialgenome,intragenomicinteraction,intergenomicinteraction,genomeintrogression	2
18.	Methods to study crop evolution - contemporary methods based on morphologicalfeatures,	2
19.	Cytogeneticanalysis,allozymevariationsandcropevolution	1
20.	DNAmarkers,genome analysisand comparativegenomics	2
21.	Evolutionarysignificanceofpolyploidy,evolutionofcropplantsthroughploidymanipulations	2
22.	Polyploids:methods,useofautopolyploids	2
23.	HaploidyandDH-methodof production and use, allopolyploids; synthesis of new crops	2
24.	Case studies – Cereals,pulses,oilseeds,vegetables,fibrecrops	2
25.	Case studies – Plantationcrops,foragecrops,tubercrops,medicinalPlants	2
Total		**48**

Suggested Readings

1. *Hancock JF. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.LadizinskyG.1999.EvolutionandDomestication.Springer.*
2. *MillerAJ.2007.CropPlants:Evolution.JohnWiley&Sons.*
3. *SmarttJandSimmondsNW.1995.EvolutionofCropPlants.*

NEMATOLOGY

Semester Wise Distribution of Courses

S. No.	Course No.	Title	Credit Hrs.
M.Sc.(Ag.)			
Semester-I			
1.	**NEMA 511***	**PRINCIPLES OF NEMATOLOGY**	**3(2+1)**
2.	**NEMA 512***	**NEMATOLOGICAL TECHNIQUES**	**3(1+2)**
3.	**NEMA 513**	**BENEFICIAL NEMATODES**	**2 (1+1)**
4.	**NEMA 514**	**DISEASE RESISTANCE IN PLANTS**	**2 (2+0)**
5.	**NEMA 515**	**PRINCIPLES OF TAXONOMY**	**2 (2+0)**
Semester-II			
1.	**NEMA 521***	**NEMATODE DISEASES OF CROPS**	**3(2+1)**
2.	**NEMA 522***	**STRUCTURAL AND FUNCTIONAL ORGANIZATION OF NEMATODES**	**3(2+1)**
3.	**NEMA 523***	**NEMATODE SYSTEMATICS**	**3(2+1)**
4.	**NEMA 524**	**NEMATODE BIOLOGY AND PHYSIOLOGY**	**3(2+1)**
5.	**NEMA 525**	**NEMATODE INTERACTIONS WITH OTHER ORGANISMS**	**3(2+1)**
Semester- III			
1.	**NEMA 531***	**NEMATODE MANAGEMENT**	**3(2+1)**
2.	**NEMA 532**	**NEMATODE ECOLOGY**	**3(2+1)**
3.	**NEMA 533**	**IPM IN PROTECTED CULTIVATION**	**3(2+1)**
4.	**NEMA 534**	**PRINCIPLES OF INTEGRATED PEST MANAGEMENT**	**2 (1+1)**
5.	**NEMA 535**	**PLANT QUARANTINE, BIOSAFETY AND BIOSECURITY**	**2 (2+0)**
6.	**NEMA 543**	**RESEARCH**	**30 (0+30)**
Semester- IV			
1.	**NEMA 541**	**SEMINAR**	**1(1+0)**
2.	**NEMA 542**	**COMPREHENSIVE**	**NC**
3.	**NEMA 543**	**RESEARCH**	**30**

M.Sc.(Ag.) Programme

NEMA 511PRINCIPLES OF NEMATOLOGY 3 (2+1)

Objectives

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

Theory

UNIT I

Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

UNIT II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

UNIT III

Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

UNIT IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

UNIT V

Principles and practices of nematode management; integrated nematode management.

UNIT VI

Emerging nematode problems, Importance of nematodes in international trade and quarantine.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Characteristics of Phylum Nematoda and its relationship with other related phyla	2
2	History and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites.	2
3	Useful nematodes (with special reference to EPNs and C elegance)	1
4	Economic importance of nematodes to agriculture, horticulture and forestry.	1
5	Gross morphology of plant parasitic nematodes.	7
6	Broad classification, nematode biology, physiology and ecology.	6
7	Types of parasitism; nature of damage and general	2

	symptomatology	
8	Interaction of plant parasitic nematodes with other organisms.	2
9	Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes	4
10	Principles and practices of nematode management; integrated nematode management.	4
11	Emerging nematode problems, Importance of nematodes in international trade and quarantine.	1
Total		**32**

Practical

Studies on kinds of nematodes- free-living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining for sedentary endoparasites; examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Studies on kinds of nematodes- free-living, animal, insect and plant parasites.	4
2	Nematode extraction from soil; extraction of migratory endoparasites.	4
3	Staining for sedentary semi endoparasite and endoparasites.	4
4	Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology	4
Total		**16**

Suggested Readings

1. *Dropkin VH. 1980. An Introduction to Plant Nematology. John Wiley & Sons, New York.*
2. *Maggenti AR. 1981. General Nematology. Springer-Verlag, New York.*
3. *Perry RN & Moens M. 2013. Plant Nematology. 2nd Ed. CABI Publishing: Wallingford, UK.*
4. *Perry RN, Moens M & Starr, JL. 2009. Root-knot nematodes, CABI Publishing: Wallingford, UK.*
5. *Thorne G. 1961. Principles of Nematology. McGraw Hill, New Delhi.*
6. *Walia RK & Bajaj HK. 2003. Text Book on Introductory Plant Nematology. ICAR, New Delhi.*
7. *Walia RK. & Khan MR. 2018. A Compendium of Nematode Diseases of Crop Plants, ICAR-AICRP (Nematodes), IARI, New Delhi.*

NEMA 512* NEMATOLOGICAL TECHNIQUES 3(1+2)

Objectives

Understanding the principles, theoretical aspects and developing skills in Nematological techniques.

Theory

UNIT I

Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipment's.

UNIT II

Survey and surveillance methods; collection of soil and plant samples; techniques for extraction of nematodes from soil and plant material; estimation of population densities.

UNIT III

Killing, fixing, clearing and mounting nematodes; measurements, preparation of perineal patterns, vulval cones of cyst nematodes, en-face views and body section of nematodes.

UNIT IV

In vitro and in vivo culturing techniques of plant parasitic, bacteriophagous, mycophagus and omnivorous nematodes.

UNIT V

Staining nematodes in plant tissues; microtomy for histopathological studies; collection of plant root exudates and their bioassay; preparation of plant materials for exhibition.

UNIT VI

Principle and theory of spectrophotometry, centrifugation, PCR, protein, DNA isolation and centrifugation techniques

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipment's.	2
2	Survey and surveillance, methods of collection of soil and plant samples.	1
3	Various techniques for extraction of nematodes from soil and plant material. Estimation of nematode population densities.	2
	Killing, fixing, clearing and mounting nematodes; measurements, preparation of perineal patterns, vulval cones of cyst nematodes, en-face views and body section of nematodes.	5
4	*In vitro* and *in vivo* culturing techniques of plant parasitic, bacteriophagous, mycophagus and omnivorous nematodes.	2
5	Staining nematodes in plant tissues; microtomy for histopathological studies; collection of plant root exudates and their bioassay; preparation of plant materials for exhibition.	2
6	Principle and theory of spectrophotometry, centrifugation, PCR, protein, DNA isolation and centrifugation techniques	2
Total		**16**

Practical

Collection of soil and plant samples; extraction of nematodes from soil by Baermann funnel, sieving and decanting, elutriation and sugar centrifugal methods; extraction of cysts from soil; extraction of nematodes from plant material; estimation of population densities; staining plant material for

nematodes; killing and fixing nematodes, clearing nematodes by slow and Seinhorst's methods; preparation of temporary and permanent mounts; measurements, drawing, microphotography, special preparation of nematodes - perineal patterns, vulval cones, en-face and body sections; collection of root exudates, preparation of exhibits of nematode diseased plant material, in vitro culturing techniques of nematodes- callous culture, excised root and carrot disc techniques.

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1.	Collection of soil and plant samples	1
2.	Extraction of nematodes from soil by Baermann funnel, sieving and decanting, elutriation and sugar centrifugal methods	4
3.	Extraction of cysts from soil; Extraction of nematodes from plant material; estimation of population densities	4
4.	Staining plant material for nematodes	2
5.	Killing and fixing nematodes, clearing nematodes by slow and Seinhorst's methods	4
6.	Preparation of temporary and permanent mounts;	2
7.	Measurements, drawing, microphotography	3
8.	Special preparation of nematodes - perineal patterns, vulval cones, en-face and body sections	4
9.	Collection of root exudates, preparation of exhibits of nematode diseased plant material	3
10.	In vitro culturing techniques of nematodes- callous culture, excised root and carrot disc techniques.	5
Total		**32**

Suggested Reading

1. *Ayoub SM. 1981. Plant Nematology – An Agricultural Training Aid.*
2. *Barker KR, Carter CC & Sasser JN 1985. An Advanced Treatise on Meloidogyne. Vol. II. Methodology. International Meloidogyne Project, NCSU, Raleigh. USA.*
3. *Manzanilla-López, RH & Marbán-Mendoza N. 2012. Practical Plant Nematology, Montecillo, Texcoco : Biblioteca Basica de Agricultura.*
4. *Southey JF. 1986. Laboratory Methods for Work with Plant and Soil Nematodes. HMSO, London.*
5. *Sikora RA, Coyne D, Hallman J and Timper P, 2018. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture.3rd edn. CABI Publishing, England.*

NEMA 513 BENEFICIAL NEMATODES2 (1+1)

Objectives

To sensitize about the use of nematodes for the biological control of insect pests of crops, and application of some nematodes as biological models and as indicators of environmental pollution.

Theory

UNIT I

Beneficial nematode fauna - predators, parasites of insects, molluscs and other pests; Entomophilic nematodes- important groups, types of nematode- insect associations; taxonomic characteristics of nematode parasites of insects.

UNIT II

Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids.

UNIT III

Entomopathogenic nematodes-Steinernema, Heterorhabditis, Oscheiustheir morphological characteristics, taxonomic status, biology and mode of action.

UNIT IV

Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.

UNIT V

Nematodes as biological models, nematodes as indicators of pollution, role of nematodes in organic matter recycling.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Beneficial nematode fauna - predators, parasites of insects, molluscs and other pests;	3
2	Entomophilic nematodes- important groups, types of nematodes-insect associations;	2
3	Taxonomic characteristics of nematode parasites of insects.	1
4	Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids.	2
5	Entomopathogenic nematodes-Steinernema, Heterorhabditis, Oscheiustheir morphological characteristics, taxonomic status, biology and mode of action.	3
6	Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.	2
7	Nematodes as biological models,	1
8	Nematodes as indicators of pollution	1
9	Role of nematodes in organic matter recycling.	1
Total		**16**

Practical

Isolation, identification, laboratory bioassay and preparation of different formulations and application methods of entomopathogenic nematodes.

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1	Isolation of entomopathogenic nematodes.	4
2	Identification of entomopathogenic nematodes.	3
3	laboratory bioassay of entomopathogenic nematodes.	3
4	Preparation of different formulations of entomopathogenic nematodes.	4
5	Application methods of entomopathogenic nematodes.	2
Total		**16**

Suggested Readings

1. *Gaugler R & Kaya HK. 1990. Entomopathogenic Nematodes in Biological Control. CRC Press, Boca Raton, Florida.*
2. *Gaugler R. 2002. Entomophilic Nematology. CABI, Wallingford.*
3. *Grewal PS, Ehlars RU & Shapiro DI. 2005. Nematodes as Biocontrol Agents. CABI, Wallingford.*
4. *Jairajpuri MS & Khan MS. 1982. Predatory Nematodes (Mononchida). Associated Publ. Co., New Delhi.*
5. *Wood WB. 1998. The Nematode Caenorhabditis elegans. Cold Spring Harbor Press. Woodring JL & Kaya HK. 1988. Steinernematid and Heterorhabditid Nematodes: A Handbook of Techniques. Southern Coop. Bull., Ark. Ag. Ext. Sta.*
6. *Zuckerman BM. (Ed.). 1980. Nematodes as Biological Models. Vols. I, II. Academic Press, New York.*

NEMA 514DISEASE RESISTANCE IN PLANTS2 (2+0)

Objectives

To acquaint with disease resistance mechanisms in plants.

Theory

UNIT I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.

UNIT II

Disease escape, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNIT III

Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

UNIT IV

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Introduction and historical development, dynamics of pathogenicity.	2
2	Process of infection, variability in plant pathogens.	3
3	Gene centers as sources of resistance.	2
4	Disease resistance terminology.	2
5	Disease escape, disease tolerance, disease resistance, types of resistance.	3
6	Identification of physiological races of pathogens,	2
7	Disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.	4

8	Host defence system, morphological and anatomical resistance,	3
9	Preformed chemicals in host defence, post infectional chemicals in host defence,	3
10	Phytoalexins, hypersensitivity and its mechanisms.	2
11	Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes.	4
12	Strategies for gene deployment.	2
Total		**32**

Suggested Reading

1. *Dallice M et al.1996. Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction. APS, St Paul, Minnesota.*
2. *Deverall BJ. 1977. Defence Mechanisms in Plants. Cambridge Univ. Press, Cambridge, New York.*
3. *Parker J. 2008. Molecular Aspects of Plant Diseases Resistance. Blackwell Publ.*
4. *Robinson RA. 1976. Plant Pathosystems. Springer Verlag, New York.*
5. *Singh BD. 2005. Plant Breeding – Principles and Methods. 7th Ed. Kalyani Publ., Ludhiana.*
6. *Van der Plank JE. 1975. Principles of Plant Infection. Academic Press, New York.*
7. *Van der Plank JE. 1978. Genetic and Molecular Basis of Plant Pathogenesis. Springer Verlag, New York.*
8. *Van der Plank JE. 1982. Host Pathogen Interactions in Plant Disease. Academic Press, New York.*
9. *Van der Plank JE. 1984. Disease Resistance in Plants. Academic Press, New York.*

NEMA 515 PRINCIPLES OF TAXONOMY 2 (2+0)

Objectives

To sensitize the students on the theory and practice of classifying organisms and the rules governing the same

Theory

UNIT I

Introduction to history and principles of systematics and importance. Levels and functions of systematics. Identification, purpose, methods- character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intra-specific variation in characters, polythetic and polymorphic taxa, sexual dimorphism.

UNIT II

Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.

UNIT III

Nomenclature: Common vs Scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of ICZN. Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Introduction to history and principles of systematics and importance. Levels and functions of systematics.	3
2	Identification, purpose, methods- character matrix, taxonomic keys.	3
3	Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intra-specific variation in characters, polythetic and polymorphic taxa, sexual dimorphism.	4
4	Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification.	3
5	Components of Biological Classification: Hierarchy, Rank, Category and Taxon.	3
6	Species concepts, cryptic, sibling and etho-species, infra-specific categories.	3
7	Introduction to numerical, biological and cytogenetical taxonomy.	2
8	Nomenclature: Common vs Scientific names.	1
9	International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of ICZN.	3
10	Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes.	7
Total		**32**

Suggested Reading

1. *Blackwelder RE. 1967. Taxonomy - A Text and Reference Book. John Wiley & Sons, New York.*
2. *Kapoor VC. 1983. Theory and Practice in Animal Taxonomy. Oxford & IBH, New Delhi.*
3. *Mayr E. 1971. Principles of Systematic Zoology. Tata McGraw-Hill, New Delhi. Quicke*
4. *DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Black i.e, London.*

NEMA 521NEMATODE DISEASES OF CROPS3 (2+1)

Objectives

To impart basic knowledge about the causal organism, nature of damage, symptoms and control of nematode diseases of agricultural and horticultural crops.

Theory

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops.

UNIT I

Cereal crops- Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum.

UNIT II

Pulses, Sugar, Fibre, Fodder and Oilseed crops- Pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugarbeet cyst and soybean cyst nematode problems.

UNIT III

Vegetable crops- root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. Nematode problems of protected cultivation.

UNIT IV

Horticultural and Ornamental crops (Citrus, Guava, Pomegranate, Papaya, Rose, Chrysanthemum, gladiolus, tuberose, jasmine, crossandra etc.), root-knot nematode, reniform nematode slow decline of citrus spreading decline of citrus, burrowing nematode and lesion nematode, Mushroom- nematode problems.

UNIT V

Plantation, medicinal and aromatic crops- burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems of coffee and tea, red ring disease of coconut. Forests- Pine wilt disease.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Ear-cockle and tundu diseases of wheat	1
2	Molya disease of wheat & Barley.	1
3	Rice root nematode disease.	1
4	Rice root-knot nematode disease.	1
5	Rice cyst nematode disease.	1
6	Ufra disease of rice.	1
7	White tip disease of rice.	1
8	Root lesion nematode disease.	2
9	Maize cyst nematode disease.	1
10	Sorghum cyst nematode disease	1
11	Pigeon pea cyst nematode	1
12	Sugarbeet cyst nematode disease.	1
13	Soyabean cyst nematode disease.	1
14	Reniform nematode disease.	2
15	Root-knot nematode disease of vegetables.	2

16	Potato cyst nematode disease.	1
17	Stem & Bulb nematode disease	1
18	Nematode problems in protected cultivation.	1
19	Citrus nematode disease.	1
20	Root-knot nematode problems in guava & pomegranate.	1
21	Nematode diseases of ornamental crops (Rose, Chrysanthemum, gladiolus, tuberose, jasmine, crossandra etc.)	2
22	Nematode problems in mushroom.	1
23	Burrowing nematode disease.	1
24	Red ring nematode disease.	1
25	Chrysanthemum foliar nematode disease.	1
26	Onion Bloat Disease	1
27	Spiral & lance nematode problem.	1
28	Problem caused by plant parasitic dorylaims.	1
Total		**32**

Practical

Diagnosis of causal organisms; identification of different life cycle stages; study of symptoms and histopathology of nematode damage in different crops, study tours for field diagnosis of nematode problems.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Diagnosis of causal organisms.	3
2	Identification of different life cycle stages.	4
3	Study of symptoms & field diagnosis of various nematode problem.	3
4	Histopathology of damage in different crops.	2
5	Identification of cyst & root-knot nematode of state.	2
6	Study tours for field diagnosis of nematode problems.	2
Total		**16**

Suggested Reading

1. *Bhatti DS & Walia RK. 1992. Nematode Pests of Crops. CBS, New Delhi.*
2. *Bridge J. & Starr JL. 2007. Plant Nematodes of Agricultural Importance: A Colour Handbook, CRC Press*
3. *Evans AAF, Trudgill DL & Webster JM. 1994. Plant Parasitic Nematodes in Temperate Agriculture. CABI, Wallingford.*
4. *Nickle WR. 1991. Manual of Agricultural Nematology. Marcel Dekker, New York.*
5. *Perry RN & Moens M. 2006. Plant Nematology. CABI, Wallingford.*
6. *Perry RN, Moens M, & Jones JT. 2018. Cyst Nematodes, CABI Publishing: Wallingford, UK. Perry RN, Moens M, & Starr, JL. 2009. Root-knot nematodes, CABI Publishing: Wallingford, UK.*

7. *Sikora R, Coyne D, Hallmann J & Timper P. 2018. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture, 3rd Ed., CABI, UK.*
8. *Walia RK & Khan MR. 2018. A Compendium of Nematode Diseases of Crop Plants, ICAR-AICRP (Nematodes), IARI, New Delhi.*

NEMA 522* STRUCTURAL AND FUNCTIONAL ORGANIZATION OF NEMATODES 3 (2+1)

Objectives

Familiarization with structural organization of nematode body so as to enable the students to understand biology, physiology and classification of nematodes.

Theory

UNIT I

Introduction and general organization of nematode body; Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom.

UNIT II

Digestive system- structural variations of stoma, oesophagus, intestine and rectum in nematodes.

UNIT III

Reproductive system- Variations in female and male reproductive systems, types of reproduction, spermatogenesis and oogenesis.

UNIT IV

Types and structure of excretory-secretory systems; nervous system and associated sense organs.

UNIT V

Embryogenesis, Cell lineage and postembryonic development; Process of hatching and moulting.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Introduction and general organization of nematode body.	3
2	Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom.	6
3	Digestive system- structural variations of stoma, oesophagus, intestine and rectum in nematodes.	6
4	Reproductive system- Variations in female and male reproductive systems, types of reproduction, spermatogenesis and oogenesis.	6
5	Types and structure of excretory-secretory systems.	2
6	Nervous system and associated sense organs.	4
7	Embryogenesis, Cell lineage and postembryonic development.	3
8	Process of hatching and moulting.	2
Total		**32**

Practical

Studies on variations in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, oesophagus, rectum; types and parts of female and male reproductive systems, sense organs, and excretory system.

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1	Studies on variations in nematode shapes and sizes.	6
2	Morphological details of cuticle, cuticular markings and ornamentation.	4
3	Studies on variations in stoma, oesophagus, rectum.	4

4	Types and parts of female and male reproductive systems, sense organs, and excretory system.	2
Total		**16**

Suggested Readings

1. *Bird AF & Bird J. 1991. The Structure of Nematodes. Academic Press, New York.*
2. *Chitwood BG & Chitwood MB. 1950. An Introduction to Nematology. Univ. Park Press, Baltimore.*
3. *Maggenti AR. 1981. General Nematology. Springer-Verlag, New York.*
4. *Malakhov VV. 1994. Nematodes: Structure, Development, Classification and Phylogeny. Smithsonian Institution Press, Washington DC.*

NEMA 523* NEMATODE SYSTEMATICS 3 (2+1)

Objective

Understanding concepts in nematode taxonomy, development of skills in the identification of plant parasitic nematodes up to genera and species levels.

Theory

UNIT I

Gross morphology, principles of nematode taxonomy -levels of taxonomy, systematics vs. taxonomy, morpho-taxonomy, molecular taxonomy, identification, classification, taxonomic categories, taxonomic characters, morphometry, Zoological nomenclature, species concept and speciation (allopatric and sympatric). Nomenclature: Common vs Scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of ICZN. Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature

UNIT II

Taxonomic position of nematodes and their relationships with allied groups; Classification and diagnoses of nematodes up to ordinal rank (Secernentea and Adenophorea)

UNIT III

Taxonomy of free-living nematodes

UNIT IV

Classification of plant parasitic nematodes; Order Tylenchida and diagnoses of its sub-orders, super families, families and important genera; Order Aphelenchida, Dorylaimida and Triplonchida and diagnoses of their important genera.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Gross morphology	1
2	Principles of nematode taxonomy -levels of taxonomy, systematics vs. taxonomy, morpho-taxonomy, molecular taxonomy,	2
3	Identification, classification, taxonomic categories, taxonomic characters.	2
4	Nomenclature & Morphometry. Zoological nomenclature Nomenclature: Common vs Scientific names.	2
5	Species concept and speciation (allopatric and sympatric).	2
6	International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under	3

	consideration of ICZN.	
7	Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature	3
8	Taxonomic position of nematodes and their relationships with allied groups;	2
9	Classification and diagnoses of nematodes up to ordinal rank (Secernentea and Adenophorea)	3
10	Taxonomy of free-living nematodes	3
11	Classification of plant parasitic nematodes; Order Tylenchida and diagnoses of its sub-orders, super families, families and important genera;	6
12	Diagnosis of order Aphelenchida, Dorylaimida and Triplonchida and diagnoses of their important genera.	3
Total		**32**

Practical

Collection of soil and plant samples from different habitats, processing and preservation of samples; and preparation of temporary mounts, processing of nematode specimens and permanent mounts. Preparation of en face view and TS of nematodes, perineal pattern of root knot nematodes and cone-top structure for cyst nematodes.

Identification of soil and plant nematodes from nematode suspension and mounted slides. Camera lucida drawing of nematodes, measurement of nematodes using traditional as well as image analyzing software.

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1	Collection of soil and plant samples from different habitats, processing and preservation of samples.	3
2	Preparation of temporary mounts, processing of nematode specimens and permanent mounts.	4
3	Preparation of en face view and TS of nematodes, perineal pattern of root knot nematodes and cone-top structure for cyst nematodes.	4
4	Identification of soil and plant nematodes from nematode suspension and mounted slides.	2
5	Camera lucida drawing of nematodes, measurement of nematodes using traditional as well as image analyzing software.	3
Total		**16**

Suggested Reading

1. *Ahmad W. & Jairajpuri MS. 2010. Mononchida: The Predatory Soil Nematodes, Series: Nematology Monographs and Perspectives, Volume: 7, Brill.*
2. *Geraert E. 2006. Tylenchida. Brill.*
3. *Hunt DJ. 1993. Aphelenchida, Longidoridae and Trichodoridae – their Systematics and Bionomics. CABI, Wallingford.*
4. *Jairajpuri MS & Ahmad W. 1992. Dorylaimida: Free-Living, Predaceous and Plant-Parasitic Nematodes, Brill.*

5. *Mai, WF, Mullin, PG, Lyon, HH, and Loeffler, K. 1996. Plant-Parasitic Nematodes: A Pictorial Key to Genera, 5th ed., Cornell University Press, London.*
6. *Siddiqi MR. 2000. Tylenchida: Parasites of Plants and Insects. 2nd Ed. CABI, Wallingford.*

NEMA 524 NEMATODE BIOLOGY AND PHYSIOLOGY 3 (2+1)

Objectives

To develop understanding of life cycle patterns, feeding and metabolic processes in phytonematodes which have implications in their management

Theory

UNIT I

Host finding and invasion, feeding, hatching, moulting; life cycle patterns in different types of nematodes.

UNIT II

Types of reproduction, gametogenesis, embryogenesis,and post embryogenesis.

UNIT III

Chemical composition of nematodes, hydrolytic enzymes, pseudocoelom and its function

UNIT IV

Physiology of digestive system, intermediary metabolism. Glycolysis, Krebs cycle and electron transport chain

UNIT V

Osmoregulation, physiology of excretory-secretory and neuromuscular systems.

Lecture Schedule-Theory

S.No.	Topics	No. of lectures
1	Host finding and invasion, feeding, hatching, moulting in nematodes.	3
2	survival and life cycle patterns in different types of nematodes.	3
3	Types of reproduction, gametogenesis, embryogenesis and post embryogenesis.	4
4	Chemical composition of nematodes.	3
5	Hydrolytic enzymes.	2
6	Pseudocoelome and its function.	3
7	Physiology of digestive system, Intermediary metabolism	4
8	Glycolysis, Krebs cycle and electron transport chain.	4
9	Osmoregulation.	2
10	Physiology of excretory-secretory and neuromuscular systems.	4
Total		**32**

Practical

Studies on embryogenesis and post-embryogenesis, hatching, moulting, life cycle development, feeding, enzymatic assay by spectrophotometry, molar, molarity, buffer, pH.

Lecture Schedule-Practical

S. No.	Topics	No. of lectures

1	Studies on embryogenesis and post-embryogenesis, hatching, moulting.	6
2	Life cycle development and feeding.	4
3	Enzymatic assay by spectrophotometry, molar, molarity, buffer, pH.	6
Total		**16**

Suggested Reading

1. *Croll NA. 1970. The Behaviour of Nematodes: The Activity, Senses and Responses. Edward Arnold, London.*
2. *Croll NA & Mathews BE. 1977. Biology of Nematodes. Blackie, Glasgow.*
3. *Lee DL. 2002. The Biology of Nematodes. Taylor & Francis, London.*
4. *Lee DL & Atkinson HJ.1976. Physiology of Nematodes. MacMillan, London.*
5. *Perry RN & Wright DJ. 1998. The Physiology and Biochemistry of Free- living and Plant Parasitic Nematodes. CABI, Wallingford.*
6. *Wallace HR. 1963. The Biology of Plant Parasitic Nematodes. Edward Arnold, London.*

NEMA 525NEMATODE INTERACTIONS WITH OTHER ORGANISMS3 (2+1)

Objectives

To understand the role of nematodes in disease complexes involving fungal, bacterial, viral and other organisms.

Theory

UNIT I

Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms.

UNIT II

Interaction of plant parasitic nematodes with wilt causing fungal pathogens and microfungi.

UNIT III

Interaction of plant parasitic nematodes with root rot and other fungal pathogens.

UNIT IV

Interaction of plant parasitic nematodes with bacterial pathogens, other nematode species and arthropods.

UNIT V

Virus transmission by nematodes..

Lecture Schedule-Theory

S.No.	Topics	No. of lectures
	Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms	7
1	Interaction of plant parasitic nematodes with wilt causing fungal pathogens and microfungi.	5
2	Interaction of plant parasitic nematodes with root rot and other fungal pathogens.	5
3	Interaction of plant parasitic nematodes with bacterial pathogens.	5
4	Nematode-nematode interaction.	3
5	Nematode-arthropods interaction.	3

6	Virus transmission by nematodes.	4
Total		**32**

Practical

Green-house experiments to study the role of plant parasitic nematodes in wilt/rot causing fungal and bacterial pathogens

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1	Study the role of plant parasitic nematodes in wilt causing fungal pathogens.	5
2	Study the role of plant parasitic nematodes in rot causing fungal pathogens.	5
3	Study the role of plant parasitic nematodes in bacterial pathogens.	6
Total		**16**

Suggested Readings:

1. *Mondia JL and Timper P 2016. Interactions of microfungi and plant parasitic nematodes. In: Biology of Microfungi (De-Wei-Lei Ed.). Springer Publications*
2. *Khan MW. 1993. Nematode Interactions. Chapman & Hall, New York.*
3. *Lamberti F, Taylor CE & Seinhorst JW. 1975. Nematode Vectors of Plant Viruses. Plenum Press, London.*
4. *Sasser JN & Jenkins WR. 1960. Nematology: Fundamentals and Recent Advances with Emphasis on Plant Parasitic and Soil Forms. Eurasia Publ. House, New Delhi.*

NEMAT 531 NEMATODE MANAGEMENT3 (2+1)

Objectives

To impart comprehensive knowledge about the principles and practices of nematode management.

Theory

UNIT I

Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.

UNIT II

Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.

UNIT III

Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil, bio- fumigation, antagonistic and trap crops, sanitation, et c.

Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material.

UNIT IV

Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods – use of antagonistic plants and antinemic plant products.

UNIT V

Genetic methods- plant resistance; legal methods- quarantine regulations; integrated nematode management- concepts and applications.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Concepts and history of nematode management.	3
2	Crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.	5
3	Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.	5
4	Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarization, time of sowing, organic amendments of soil, bio-fumigation, antagonistic and trap crops, sanitation etc.	4
5	Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material	4
6	Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use.	4
7	Phytotherapeutic methods – use of antagonistic plants and antinemic plant products.	3
8	Genetic methods- plant resistance; legal methods- Plant bio-security, quarantine regulation;	2
9	Integrated nematode management- concepts and applications.	2
Total		**32**

Practical

In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods; methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on biocontrol potential of fungal, bacterial parasites, and predacious fungi and nematodes. Probit analysis and LD 50 value, to test the strength and efficacy of newer approaches in protected cultivation

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	In vitro screening of synthetic chemicals and plant products	3

	for nematicidal activity, and their application methods.	
2	Methods for screening of crop germplasm for resistance against nematodes.	3
3	Laboratory exercises on bio control potential of fungal parasites and predacious fungus against root-knot nematode.	3
4	Laboratory exercises on bio control potential of bacterial parasites against root-knot nematode.	3
5	Laboratory exercises on bio control potential of nematodes.	2
6	Probit analysis and LD 50 value, to test the strength and efficacy of newer approaches in protected cultivation	2
Total		**16**

Suggested Readings

1. *Bhatti DS & Walia RK. 1994. Nematode Pest Management in Crops. CBS, New Delhi.*
2. *Brown GL. 1977. The Nematode Destroying Fungi. CBP, Guelph.*
3. *Brown RH & Kerry BR. 1987. Principles and Practice of Nematode Control in Crops. Academic Press, Sydney.*
4. *Chen ZX, Chen SY& Dickson DW. 2004. Nematology: Advances and Perspectives. Vol. II: Nematode Management and Utilization. CABI, Wallingford.*
5. *Perry RN & Moens M. 2013. Plant Nematology. 2nd Ed., CABI, Wallingford, London.*
6. *Starr JL, Cook R & Bridge J. 2002. Plant Resistance to Parasitic Nematodes. CABI, Wallingford.*
7. *Stirling GR. 2014. Biological Control of Plant-parasitic Nematodes, 2nd Ed., CAB International, UK.*
8. *Whitehead AG. 1997. Plant Nematode Control. CABI, Wallingford.*

NEMA 532 NEMATODE ECOLOGY 3 (2+1)

Objectives

To understand the life of plant parasitic nematodes in their environment; their survival strategies, and how to exploit these for their control.

Theory

UNIT I

Definition and scope; components of environment; evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.

UNIT II

Role of nematodes in the food web; habitat and niche characteristics; community analysis and population estimation models.

UNIT III

Effects of abiotic and biotic factors on nematodes.

UNIT IV

Environmental extremes and nematode behavior- aggregation, swarming, orientation, feeding and reproduction.

UNIT IV

Survival strategies of nematodes in adverse environment and absence of host.

UNIT V

Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Definition and scope; components of environment. Evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.	4
2	Role of nematodes in the food web; habitat and niche characteristics; community analysis and population estimation models.	5
3	Effects of abiotic factors on nematodes.	3
4	Effects of biotic factors on nematodes.	3
5	Environmental extremes and nematode behaviour- aggregation, swarming, orientation, feeding and reproduction.	4
6	Survival strategies of nematodes in adverse environment and absence of host.	4
7	Modeling population dynamics and relations with crop performance	4
8	Ecological considerations in nematode management, data interpretation and systems simulation.	5
Total		**32**

Practical

Study of nematode fauna in varied agro-ecological systems, community analysis of nematode populations, laboratory exercises on influence of abiotic factors on movement and hatching, green-house experiments on effect of abiotic factors on nematode populations and plant growth.

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1	Study of nematode fauna in varied agro-ecological systems	4
2	Community analysis of nematode populations.	4
3	Laboratory exercises on influence of abiotic factors on movement and hatching.	4
4	Green-house experiments on effect of abiotic/biotic factors on nematode populations and plant growth.	4
Total		**16**

Suggested Readings

1. *Croll NA. 1970. The Behaviour of Nematodes: The Activity, Senses and Responses. Edward Arnold, London.*
2. *Croll NA & Mathews BE. 1977. Biology of Nematodes. Blackie, Glasgow.*
3. *Lee DL. 2002. The Biology of Nematodes. Taylor & Francis, London.*

4. *Gaugler, R. and Bilgrami, AL. 2004. Nematode Behaviour, CABI, UK*
5. *Norton DC. 1978. Ecology of Plant Parasitic Nematodes. John Wiley.*
6. *Poinar G. 1983. Natural History of Nematodes. Prentice Hall, Englewood Cliffs.*
7. *Wallace HR. 1973. Nematode Ecology and Plant Disease. Edward Arnold, London.*

NEMA 533 IPM IN PROTECTED CULTIVATION3 (2+1)

Objectives

To sensitize the pest and disease scenario developing in crops raised under protected cultivation and to impart knowledge about the remedy.

Theory

UNIT I

Characteristics of protected cultivation and tools for sustainable crop production; outline of major biotic stresses in protected cultivation including: fungi, bacteria, virus, nematode, insects and mites.

UNIT II

Sampling and monitoring pests and diseases; epidemiology and damage relationships; loss assessment; population dynamics of biotic stress agents; factors responsible for severity of pests and diseases.

UNIT III

Host plant resistance to pathogens and insects; management strategies for protected cultivation: disinfestation of soil and growth media; preventive, scouting and early detection; and curative measures: biological control of sap sucking pests, leaf miners; soil- and air-borne pathogens; pesticides selectivity, applications and resistance management; buzz pollination.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Characteristics of protected cultivation and tools for sustainable crop production.	2
2	Outline of major biotic stresses in protected cultivation including: fungi, bacteria, virus, nematode, insects and mites.	3
3	Sampling and monitoring pests and diseases.	2
4	Epidemiology and damage relationships.	3
5	Loss assessment	2
6	Population dynamics of biotic stress agents	2
7	Factors responsible for severity of pests and diseases.	3
8	Host plant resistance to pathogens and insects	3
9	Management strategies for protected cultivation: disinfestation of soil and growth media preventive, scouting and early detection; and curative measures	4
10	Biological control of sap sucking pests, leaf miners; soil- and air-borne pathogens	4
11	Pesticides selectivity, applications and resistance management; buzz pollination.	4
Total		**32**

Practical

Visit to familiarize with pest and disease situations developing in protected cultivation; symptomatology and damages; identification of the causes; estimation of population densities;

management tactics/ approaches and recommendations; production and commercialization of biological agents.

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1	Visit to familiarize with pest and disease situations developing in protected cultivation.	4
2	Symptomatology and damages; identification of the causes	4
3	Estimation of population densities	4
4	Management tactics/ approaches and recommendations; production and commercialization of biological agents.	4
Total		**16**

Suggested Readings:

1. *Gullino, M.L., Albajes, R. and Nicot, P. 2019. Integrated Pest and Disease Management in Greenhouse Crops. Ed. 2nd, Springer, New York.*
2. *Rathee et al. 2018. Integrated Pest Management under Protected Cultivation – A Review. Journal of Entomology and Zoology Studies, 6 (2): 1201 – 1208*

NEMA 534 PRINCIPLES OF INTEGRATED PEST MANAGEMENTENT 2 (1+1)

Objectives

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM. Train students in computation of ETL, implementing IPM programmes.

Theory

UNIT I

History and origin, definition and evolution of various related terminologies.

UNIT II

Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

UNIT III

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	History and origin, definition and evolution of various related terminologies.	2
2	Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.	2
3	Tools of pest management and their integration- legislative, cultural, physical and mechanical methods.	2
4	Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys.	2
5	Political, social and legal implications of IPM.	1
6	Pest risk analysis.	1

7	Pesticide risk analysis.	2
8	Cost-benefit ratios and partial budgeting.	2
9	Case studies of successful IPM programmes.	2
Total		**16**

Practical

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment- direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system

Lecture Schedule-Practical

S. No.	Topics	No. of lectures
1	Characterization of agro-ecosystems, sampling methods and factors affecting sampling	4
2	Population estimation methods	4
3	Crop loss assessment- direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses	4
4	Computation of EIL and ETL; crop modeling; designing and implementing IPM system.	4
Total		**16**

Suggested Readings

1. *Dhaliwal GS & Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publ., New Delhi.*
2. *Dhaliwal GS, Ram Singh & Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.*
3. *Flint MC & Bosch RV. 1981. Introduction to Integrated Pest Management. 1st Ed., Springer, New York.*
4. *Horowitz AR & Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi.*
5. *Ignacimuthu SS & Jayaraj S. 2007. Biotechnology and Insect Pest Management. Elite Publ., New Delhi.*
6. *Metcalf RL & Luckman WH. 1982. Introduction of Insect Pest Management. John Wiley & Sons, New York.*
7. *Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi.*
8. *Norris RF, Caswell-Chen EP & Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.*
9. *Subramanyam B & Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.*

NEMA 535 PLANT QUARANTINE, BIOSAFETY AND BIOSECURITY 2 (2+0)

Objectives

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

UNIT III

Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.

UNIT IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Lecture Schedule-Theory

S. No.	Topics	No. of lectures
1	Definition of pest, pesticides and transgenics as per Govt. notification; relative importance;	3
2	Quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.	5
3	Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003.	3
4	Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.	3
5	Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination.	5
6	Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.	4
7	WTO regulations; non-tariff barriers;	2
8	Pest risk analysis,	4
9	Good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.	3
Total		**32**

Suggested Reading

1. *Rajeev K & Mukherjee RC. 1996. Role of Plant Quarantine in IPM. Aditya Books.*
2. *Rhower GG. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.*
3. *Shukla, A. and Veda, O.P. 2007. Introduction to Plant Quarantine. Samay Prakashan, New Delhi.*

PLANT PATHOLOGY

Semester Wise Distribution of Courses

S.No.	Course No.	Title	Credit Hrs.
M.Sc. (Ag.) Semester-I			
1	**PPATH-511***	**MYCOLOGY**	**3(2+1)**
2	**PPATH-512***	**TECHNIQUES IN DETECTION AND DIAGNOSIS OF PLANT DISEASES**	**2(0+2)**
3	**PPATH-513***	**PRINCIPLES OF PLANT PATHOLOGY**	**3(2+1)**
Minor Courses			
4	**ENT-513**	**CONCEPT OF INTEGRATED PEST MANAGEMENT**	**2(2+0)**
Supporting Courses			
5	**STAT-511**	**STATISTICAL METHOD FOR APPLIED SCIENCES**	**3(2+1)**
Common Courses			
6	**PGS-511**	**LIBRARY AND INFORMATION SERVICES**	**1(0+1)**
		Total	**14**
Semester-II			
1	**PPATH-521***	**PLANT PATHOGENIC PROKARYOTES**	**3(2+1)**
2	**PPATH-522***	**PRINCIPLES OF PLANT DISEASE MANAGEMENT**	**3(2+1)**
3	**PPATH-523***	**DISEASES OF FIELD, MEDICINAL AND SPICES CROPS**	**3(2+1)**
Minor Courses			
4	**ENT-524/PPHYS-521/NEMA-521**	**PEST OF FIELD CROPS/PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANT TO ABIOTIC STRESSES**	**3(2+1)**
Supporting Courses			
5	**BIOCHEM-521**	**BASIC BIOCHEMISTRY**	**3(2+1)**
Total			**15**
Semester-III			
1	**PPATH-531**	**PLANT VIROLOGY***	**3(2+1)**
Minor Courses			

2	**ENT-531**	**PEST OF HORTICULTURAL AND PLANTATION CROP**	**3(2+1)**
Common Courses			
3.	**PGS -531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4.	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5.	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6.	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
7	**PPATH-543**	**RESEARCH**	**30**
Semester-IV			
1	**PPATH-541**	**SEMINAR**	**1(0+1)**
2	**PPATH-542**	**COMPREHENSIVE**	**NC**
3	**PPATH-543**	**RESEARCH**	**30**
Ph.D. Plant Pathology			
Semester-I			
1	**PPATH-611**	**ADVANCES IN VIROLOGY**	**3(2+1)**
2	**PPATH-612****	**MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION**	**3(2+1)**
Minor Courses			
3	**ENT-533**	**PEST OF HORTICULTURAL AND PLANTATION CROPS**	**3(2+1)**
Supporting Courses			
4	**ENT-513/NEMA-511**	**CONCEPTS OF INTEGRATED PEST MANAGEMENT/PRINCIPLES OF NEMATOLOGY**	**2(2+0)**
Total			**11**
Semester-II			
1	**PPATH-621**	**ADVANCES IN MYCOLOGY**	**3(2+1)**
2	**PPATH-622**	**ADVANCES IN PLANT PATHOGENIC PROKARYOTES**	**3(2+1)**
Minor Courses			
3	**ENT-524/NEMA-521/PPHYS-521/ NEMA-525**	**PEST OF FIELD CROPS/NEMATODE DISEASES OF CROPS/PHYSIOLOGICAL AND**	**3(2+1)**

		MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES/ NEMATODE INTERACTIONS WITH OTHER ORGANISMS	
Supporting Courses			
4	**BIOCHEM-522**	**TECHNIQUES IN BIO-CHEMISTRY**	**3(2+1)**
Total			**12**
Semester-IIIand onward			
1	**PPATH 641**	**DOCTORAL SEMINAR – I**	**1(0+ 1)**
2	**PPATH 642**	**DOCTORAL SEMINAR – II**	**1(0+ 1)**
3	**PPATH 643**	**COMPREHENSIVE**	**NC**
4	**PPATH 644**	**DOCTORAL RESEARCH**	**75**
Non Core Courses			
1	**PPATH-514**	**DISEASE RESISTANCE IN PLANTS**	**2(2+0)**
2	**PPATH- 524**	**INTEGRATED DISEASE MANAGEMENT**	**3(2+1)**
3	**PPATH-525**	**POST-HARVEST DISEASES**	**3(2+1)**
4	**PPATH-532**	**DISEASES OF FRUITS, VEGETABLES, PLANTATION AND ORNAMENTAL CROPS**	**3(2+1)**

*CORE COURSES FOR MASTER'S ** CORE COURSES FOR DOCTORAL PROGRAMME

M.Sc. (Ag.) Programme

PPATH 511 MYCOLOGY3(2+1)

Objectives

To study the nomenclature, classification and characters of fungi.

Theory

UNIT I

Introduction, definition of different terms, basic concepts.Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom Fungi, Stramenopila and Protists.

UNIT II

The general characteristics of Protists and life cycle in the Phyla - Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

UNIT III

Kingdom Fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota :- Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.

UNIT IV

Basidiomycota :- general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes. Uridinales and Ustilaginales:- variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi:- status of asexual fungi, their teliomorphic relationships. Molecular characterization of plant pathogenic fungi.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	General Introduction.	1
2.	Basic concept and definition of different terms.	3
3.	Importance of mycology in agriculture, relation of fungi to human affairs.	1
4.	History of mycology.	1
5.	Importance of culture collection and herbarium of fungi.	1
6.	Somatic characters and reproduction in fungi.	2
7.	Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.	2
8.	The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota.	2
9.	Kingdom Stramenopila: characters and life cycles of respective	3

	genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.	
10.	Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota,Zygomycota,Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes,Loculoascomycetes, Erysiphales and anamorphs of ascomycetousfungi.	- 2 2 4
11	Basidiomycota; general characters, mode of reproduction, types of basidiocarps. Economic importance of Hymenomycetes. Uridinales and Ustilaginales. Variability, host specificity and life cycle pattern in rusts and smuts.	2 2 1
12	Mitosporic fungi; status of asexual fungi, their teliomorphic relationships.	2
13	Molecular characterization of plant pathogenic fungi.	1
Total		**32**

Practical

Detailed comparative study of different groups of fungi; Collection of cultures and live specimens. Saccardoan classification and classification based on conidiogenesis. Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi. Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia. Oomycota; somatic and reproductory structures of Pythium, Phytophthora, downy mildews and Albugo, Zygomycetes: Sexual and asexual structures of Mucor, Rhizopus, General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales, and Eurotiales; general identification characters of Pyrenomycetes, Discomycetes, Loculoascomycetes and Laboulbeniomycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes; characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi. Application of molecular approaches and techniques for identification of fungalpathogens.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Saccardoan classification and classification based on conidiogenesis.	1
2.	Vegetative structures and different types of fruiting bodies produced by slimemolds, stramenopiles and true fungi.	2
3.	Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium andaethalia.	1

4.	Oomycota; somatic and reproductory structures of Pythium, Phytophthora, downy mildews and Albugo.	2
5.	Zygomycetes: Sexual and asexual structures of Mucor, Rhizopus.	1
6.	General characters of VAM fungi.	1
7.	Ascomycetes; fruiting structures, Erysiphales, and Eurotiales; general identification characters of Pyrenomycetes, Discomycetes, Loculoascomycetes and Laboulbeniomycetes.	2
8.	Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes.	2
9.	Deuteromycetes; characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states.	2
10	Collection, preservation, culturing and identification of plant parasitic fungi.	1
11.	Application of molecular approaches and techniques for identification of fungal pathogens.	1
Total		***16***

Suggested Readings

1. *Ainsworth GC, Sparrow FK & Susman HS. 1973. The Fungi – An Advanced Treatise. Vol. IV (A & B).Academic Press, New York.*
2. *Alexopoulos CJ, Mims CW & Blackwell M. 2000.Introductory Mycology.5th Edn. John Wiley & Sons, New York.*
3. *Dube H.C. 2020. An Introduction to Fungi.5th Ed. Scientific Publisher, Jodhpur, India.*
4. *Agrios G.N. 2006.Plant Pathology. 5thEd. Elesvier Science.*
5. *Maheshwari R 2016. Fungi: Experimental Methods in Biology 2nd Edn. CRC Press, US.Mehrotra R.S. &Aneja K.R. 1990.An Introductory Mycology. Wiley Eastern, New Delhi.Sarbhoy AK. 2000. Text Book of Mycology. ICAR, New Delhi.*
6. *Singh RS. 1982. Plant Pathogens – The Fungi. Oxford & IBH, New Delhi.*
7. *Webster J. 1980. Introduction to Fungi.2nd Ed. Cambridge Univ. Press, Cambridge, New York.*

PPATH 512 TECHNIQUES FOR DETECTION AND DIAGNOSIS OF PLANT DISEASES 2(0+2)

Objectives

To impart training on various methods/techniques/instruments used in the study of plantdiseases/ pathogens

Practical

Detection of plant pathogens: 1.Based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid based techniques (Non-PCR– LAMP, Later flow microarray & PCR based- multiplex, nested, qPCR, immune capture PCR, etc.). Phenotypic and genotypic tests for identification of plant pathogens. Molecular identification (16S rDNA and 16s-23S r DNA intergenic spacer region

sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing. Volatile compounds profiling by using GC-MS and LC-MS. FAME analysis, Fluorescence in-situ Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens. Genotypic tools such as genome/specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Detection of plant pathogens 1. Based on visual symptoms.	1
	2. Biochemical test.	1
	3. Using microscopic techniques.	1
	4. Cultural studies; (use of selective media to isolate pathogens).	1
	5. Biological assays (indicator hosts, differential hosts).	2
	6. Serological assays.	4
	7. Nucleic acid based techniques (Non-PCR– LAMP, Later flow microarray & PCR based- multiplex, nested,qPCR, immune capture PCR, etc.).	4
2	Phenotypic and genotypic tests for identification of plant pathogens.	4
3	Molecular identification (16S rDNA and 16s-23S rDNAintergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing.	2
4	Volatile compounds profiling by using GC- MS and LC-MS. FAME analysis.	2
5	Fluorescence in-situ Hybridization (FISH).	2
12	Flow Cytometry.	2
13	Phage display technique.	2
14	Biosensors for detection of plant pathogens.	1
15	Genotypic tools such as genome/specific gene sequence homology comparison by BLAST (NCBI and EMBL).	2
16	Electron microscopy techniques of plant virus detection and diagnosis.	1
Total		**32**

Suggested Readings

1. *Balaji Aglave 2019. Handbook of Plant Disease Identification and Management CRC Press Taylor & Francis Group*
2. *Baudoin ABAM, Hooper GR, Mathre DE & Carroll RB. 1990. Laboratory Exercises in Plant Pathology: An Instructional Kit. Scientific Publ., Jodhpur.*

3. *Dhingra OD & Sinclair JB. 1986. Basic Plant Pathology Methods. CRC Press, London, Tokyo. Fox RTV. 1993. Principles of Diagnostic Techniques in Plant Pathology, CABI Wallington.*
4. *Mathews REF. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Boca Raton, Tokyo. Pathak VN. 1984. Laboratory Manual of Plant Pathology. Oxford & IBH, New Delhi.*
5. *Forster D & Taylor SC. 1998.Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology.Humana Press, Totowa, New Jersey.*
6. *Matthews REF. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Florida.*
7. *Noordam D. 1973.Identification of Plant Viruses, Methods and Experiments. Cent. Agic. Pub. Doc. Wageningen.*
8. *Trigiano RN, Windham MT & Windham AS. 2004. Plant Pathology-Concepts and Laboratory Exercises. CRC Press, Florida.Chakravarti BP. 2005.Methods of Bacterial Plant Pathology.Agrotech, Udaipur.*

PPATH 513 PRINCIPLES OF PLANT PATHOLOGY3(2+1)

Objectives

To introduce the subject of Plant Pathology, its concepts and principles.

Theory

UNIT I

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

UNIT II

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

UNIT III

Host- parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

UNIT IV

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

UNIT V

IDM in protected cultivation.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Importance, definitions and concepts of plant diseases.	1
2.	History and growth of plant pathology.	1

3.	Biotic and abiotic causes of plantdiseases.	1
4.	Growth, reproduction of plant pathogens.	2
5.	Survival and dispersal of important plant pathogens,	3
6.	Role of environment and host nutrition on diseasedevelopment.	2
7.	Host parasite interaction, recognition concept and infection.	3
8.	Symptomatology.	1
9.	Disease development- role of enzymes, toxins, growth regulators.	3
10.	Defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors.	2
11.	Altered plant metabolism as affected by plant pathogens.	2
12.	Genetics of resistance; 'R' genes.	2
13.	Mechanism of genetic variation in pathogens.	2
14.	Molecular basis for resistance; marker-assisted selection.	3
15.	Genetic engineering for disease resistance.	2
16.	IDM in protected cultivation.	2
Total		**32**

Practical

Basic plant pathological techniques. Isolation, inoculation and purification of plant pathogens and proving Koch's postulates. Techniques to study variability in different plant pathogens. Purification of enzymes, toxins and their bioassay. Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Basic plant pathological techniques.	3
2.	Isolation, Inoculation and purification of plant pathogens and proving Koch's postulates.	2
3.	Techniques to study variability in different plant pathogens.	3
4.	Purification of enzymes, toxins and their bioassay.	4
5.	Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.	4
Total		**16**

Suggested Readings

1. *Agrios, G.N. 2005. Plant Pathology. 5th Edn. Academic Press, New York.*
2. *Aneja, K.R. 2017. Experiments in microbiology, Plant Pathology, tissue culture &Microbial Biotechnology. 5th Edn.New Age International Publishers, New Delhi.*
3. *S. G. Borkar 2017. History of Plant Pathology. Woodhead Publishing India Pvt. Ltd., New Delhi, India*
4. *Heitefuss R. & Williams P.H. 1976.Physiological Plant Pathology.Springer Verlag, Berlin, New York.*

5. *Mehrotra R.S. &Aggarwal A. 2003.Plant Pathology.2nd Ed. Oxford & IBH, New Delhi.*
6. *Singh R.S. 2017.Introduction to Principles of Plant Pathology.5th edn.MedTech, New Delhi.*
7. *Singh R.P. 2012. Plant Pathology 2nd edn.Kalyani Publishers, New Delhi.*
8. *Singh D.P. & Singh A. 2007.Disease and Insect Resistance in Plants.Oxford & IBH, New Delhi*
9. *.Upadhyay RK & Mukherjee KG. 1997. Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH, New Delhi.*

PPATH514DISEASE RSISTANCEINPLANTS2(2+0)

Objectives

To acquaint with the disease resistance mechanisms.

Theory

UNIT I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escape, non-host resistance and disease tolerance.

UNIT II

Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNITIII

Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defense, post infectional chemicals in host defense, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Introduction and historical development of plant disease resistance.	2
2.	Dynamics of pathogenicity, process of infection.	2
3.	Variability in plant pathogens, gene centres as sources of resistance.	2
4.	Disease resistance terminologies.	1
5.	Disease escape, non-host resistance and disease tolerance.	2
6.	Genetic basis of disease resistance, types of resistance.	2
7.	Identification of physiological races of pathogen, disease progression in relation to resistance.	3
8.	Disease progression in relation to resistance.	2
9.	Stabilizing selection pressure in plant pathogens.	2
10.	Host defence system, morphological and anatomical resistance.	2
11.	Pre-formed chemicals in host defence and post infectional	2

	chemicals in host defence.	
12.	Phytoalexins, hypersensitivity and its mechanisms.	2
13.	Genetic basis of relationships between pathogen and host.	2
14.	Gene-for-gene concept and protein-for-protein.	2
15.	Immunization basis, management of resistance genes.	2
16.	Strategies for gene deployment.	2
Total		**32**

Suggested Readings

1. *Deverall BJ. 1977. Defence Mechanisms in Plants. Cambridge Univ. Press, Cambridge, New York.*
2. *Mills Dallice et al.1996. Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction. APS, St Paul, Minnesota.*
3. *Parker J. 2008. Molecular Aspects of Plant Diseases Resistance. Blackwell Publ.*
4. *Robinson RA. 1976. Plant Pathosystems. Springer Verlag, New York.*
5. *Singh BD. 2005. Plant Breeding – Principles and Methods. 7th Ed. Kalyani Publ., Ludhiana*
6. *Van der Plank JE. 1975. Principles of Plant Infection. Academic Press, New York.*

PPATH 521Plant Pathogenic Prokaryotes3(2+1)

Objectives

To acquaint with plant pathogenic prokaryote (Procarya) and their structure, nutritional requirements, survival and dissemination.

Theory

UNIT I

Prokaryotic cell: History and development of plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins.Structure of bacterial cell. Structure and composition of Gram negative and Gram positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccaride structure; Membrane transport; fimbrae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological features of fastidious bacteria, spiroplasmas and Phytoplasmas.

UNIT II

Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.

UNIT III

Taxonomy of phytopathogenicprokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

UNIT IV

Variability among phytopathogenicprokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.

UNIT V

Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, Use of phages in plant pathology/bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India.	2
2	Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins.	1
3	Structure of bacterial cell.	2
4	Structure and composition of Gram negative and Gram positive cell wall; synthesis of peptidoglycan; Surface proteins.	2
5	Lipopolysaccaride structure; Membrane transport; fimbrae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S-layer; capsule).	1
6	The bacterial chromosomes and plasmids; Operon and other structures in cytoplasm.	4
7	Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.	2
8	Growth and nutrition requirements of bacteria.	3
9	Infection mechanism, role of virulence factors in expression of symptoms.	2
10	Survival and dispersal of phytopathogenic prokaryotes.	1
11	Taxonomy of phytopathogenic Prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma.	2
12	The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic Prokaryotes.	2
13	Variability among phytopathogenic Prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.	1
14	Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells.	2
15	Phage multiplication cycle; Classification of phages, Use of phages in plant pathology/bacteriology, Lysogenic conversion; H	2

	Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins.	
16	Strategies for management of diseases caused by phytopathogenic prokaryotes.	3
Total		**32**

Practical

Study of symptoms produced by phytopathogenic prokaryotes. Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria. Stains and staining methods. Biochemical and serological characterization. Isolation of genomic DNA plasmid. Use of antibacterial chemicals/antibiotics. Isolation of fluorescent Pseudomonas. Preservation of bacterial cultures. Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences. Diagnosis and management of important diseases caused by bacteria and mollicutes.

Lecture Schrdule-Practical

S. No.	Topics	No. of Lectures
1	Study of symptoms produced by phytopathogenic prokaryotes.	1
2	Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria.	2
3	Stains and staining methods.	1`
4	Biochemical and serological characterization.	2
5	Isolation of genomic DNA plasmid.	2
6	Use of antibacterial chemicals/antibiotics.	2
7	Isolation of fluorescent Pseudomonas. Preservation of bacterial cultures.	2
8	Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences.	2
9	Diagnosis and management of important diseases caused by bacteria and mollicutes.	2
Total		**16**

Suggested Readings

1. *Borkar S. G. 2018. Laboratory Techniques in Plant Bacteriology, CRC Press Taylor & Francis Group*
2. *Goto M. 1990. Fundamentals of Plant Bacteriology. Academic Press, New York.*
3. *Jayaraman J & Verma J.P. 2002. Fundamentals of Plant Bacteriology. Kalyani Publ., Ludhiana.*
4. *Mount M.S. & Lacy G.H. 1982. Phytopathogenic Prokaryotes. Vols.I, II Academic Press, New York.*
5. *Salle A.J. 1979. Fundamental Principles of Bacteriology 7thEdn.*
6. *Verma J.P., Varma A & Kumar D. (Eds). 1995. Detection of Plant Pathogens and their Management. Angkor Publ., New Delhi.*

PPATH 522 PRINCIPLES OF PLANT DISEASEMANAGEMENT 3(2+1)

Objectives

To acquaint with different strategies for management of plant diseases

Theory

UNIT I

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

UNIT II

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.

UNIT III

Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health vis-à-vis environmental hazards, residual effects and safety measures.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Principles of plant disease management by cultural methods.	2
2	Principles of plant disease management by physical methods.	2
3	Principles of plant disease management by biological methods.	2
4	Principles of plant disease management by chemical methods.	2
5	Principles of plant disease management by organic amendments.	2
6	Principles of plant disease management by botanicals.	2
7	Integrated control measures of plant diseases.	2
8	Disease resistance and molecular approach for disease management.	3
9	History of fungicides, bactericides, antibiotics.	2
10	Concepts of pathogen, immobilization.	2
11	Chemical protection and chemotherapy.	2
12	Nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.	2
13	Label claim of fungicides.	1
14	Application of chemicals on foliage, seed and soil.	2
15	Role of stickers, spreaders and other adjuvants.	1
16	Health vis-a-visenvironmental hazards.	2
17	Residual effects and safety measures.	1
Total		**32**

Practical :

Phytopathometry. Methods of in vitro evaluation of chemicals, antibiotics, bio agents against plant pathogens. Field evaluation of chemicals, antibiotics, bio agents against plant pathogens. Soil solarisation, methods of soil fumigation under protected cultivation. Methods of application of chemicals and bio control agents. ED and MIC values, study of structural details of sprayers and dusters. Artificial epiphytotic and screening of resistance.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Phytopathometry.	2
2	Methods of in vitro evaluation of chemicals, antibiotics, bio agents against plant pathogens.	2
3	Field evaluation of chemicals, antibiotics, bio agents against plant pathogens.	2
4	Soil solarisation.	2
5	Methods of soil fumigation under protected cultivation.	2
6	Methods of application of chemicals and bio control agents.	2
7	ED and MIC values.	2
8	Study of structural details of sprayers and dusters.	1
9	Artificial epiphytotic and screening of resistance.	1
Total		**16**

Suggested Readings

1. *Fry W.E. 1982. Principles of Plant Disease Management. Academic Press, New York.*
2. *Hewitt H.G. 1998. Fungicides in Crop Protection. CABI, Wallington.*
3. *Marsh R.W. 1972. Systemic Fungicides. Longman, New York.*
4. *Nene Y.L. &Thapliyal PN. 1993. Fungicides in Plant Disease Control. Oxford & IBH, New Delhi.*
5. *Palti J. 1981. Cultural Practices and Infectious Crop Diseases. Springer Verlag, NewYork.*
6. *Vyas S.C. 1993. Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.*

PPATH 523 DISEASES OF FIELD, MEDICINAL AND SPICES CROPS3(2+1)

Theory

UNIT I

Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize.

UNIT II

Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

UNIT III

Diseases of Oilseed crops- Rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

UNIT IV

Diseases of Cash crops- Cotton, sugarcane and tobacco.

UNIV V

Diseases of Fodder legume crops- Berseem, oats, guar, lucerne,

UNIT VI

Medicinal crops- Plantago, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, Aloe vera

UNIT VII

Seed Spices- Cumin, coriander, fennel and fenugreek

Lecture Schedule-Theory

S.No.	Topics	No. of Lecturers
1.	General introduction.	1
2.	Diseases of rice.	2
3.	Diseases of wheat.	3
4.	Diseases of barley.	2
5.	Diseases of pearl millet .	2
6.	Diseases of sorghum and maize.	2
7.	Diseases of gram.	2
8.	Diseases of urdbean, mothbean, mungbean, cowpea and lentil.	2
9.	Diseases of pigeonpea and soybean.	2
10.	Diseases of rapeseed and mustard, linseed and sesame.	2
11.	Diseases of sunflower and caster.	1
12.	Diseases of groundnut.	1
13.	Diseases of cotton.	1
14.	Diseases of sugarcane and tobacco.	1
15.	Diseases of berseem, lucerne oats and guar.	1
16.	Diseases of plantago, liquorice and mulathi.	2
17	Diseases of rosagrass, sacred basil and menthe.	2
18.	Diseases of opium, ashwagandha and aloe vera.	1
19	Seed Spices- cumin, coriander, fennel and fenugreek.	2
Total		**32**

Practical

Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops. Collection and dry preservation of diseased specimens of important crops

Lecture Schedule-Practical

S.No.	Topics	No. ofLecturers
1.	Study of symptoms and host parasite relationship of diseases of wheat.	2
2.	Study of symptoms and host parasite relationship of diseases of barley.	1
3.	Study of symptoms and host parasite relationship of diseases of pearl millet.	1
4.	Study of symptoms and host parasite relationship of diseases of	1

	sorghum & maize.	
5.	Study of symptoms and host parasite relationship of diseases of gram.	1
6.	Study of symptoms and host parasite relationship of diseases of mothbean & mung.	1
7.	Study of symptoms and host parasite relationship of diseases of mustard.	1
8.	Study of symptoms and host parasite relationship of diseases of linseed.	1
9.	Study of symptoms and host parasite relationship of diseases of castor.	1
10.	Study of symptoms and host parasite relationship of diseases of groundnut.	1
11.	Study of symptoms and host parasite relationship of diseases of cotton.	1
12.	Study of symptoms and host parasite relationship of diseases of fodder legumes and medicinal plants.	2
13	Study of symptoms and host parasite relationship of diseases of Seed Spices- cumin, coriander, fennel and fenugreek.	1
14	Collection and Dry preservation of diseased specimen of important crops	1
Total		**16**

Suggested Readings

1. *Joshi L M, Singh D.V. & Srivastava K. D. 1984. Problems and Progress of Wheat Pathology in South Asia. Malhotra Publ. House, New Delhi.*
2. *Mehrotra R.S. and Aggarwal A. 2017. Plant Pathology, 3rd Edn. McGraw Hill Education, New Delhi.*
3. *Rangaswami G. 1999. Diseases of Crop Plants in India. 4th Ed.Prentice Hall of India, New Delhi.*
4. *Ricanel C, Egan B.T, Gillaspie Jr A.G & Hughes C.G. 1989. Diseases of SugarcaneMajor Diseases. Academic Press, New York.*
5. *Singh R.S. 2017. Plant Diseases. 10th Ed. Medtech, New Delhi.*
6. *Singh U.S, Mukhopadhyay A.N, Kumar J & Chaube H.S. 1992. Plant Diseases of International Importance. Vol. I. Diseases of Cereals and Pulses. Prentice Hall, Englewood Cliffs, New Jersey.*

PPATH524INTEGRATEDDISEASEMANAGEMENT3 (2+1)

Objectives

To emphasize the importance and the need of IDM in the management of diseases of importantcrops**.**

Theory

UNITI

Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

UNIT II

Development of IDM-basic principles, biological, chemical and cultural disease management.

UNIT III

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses, vegetable crops, fruit, plantation and spice crops.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Introduction, definition, concept and tools of disease management	1
2.	Components of integrated disease management- their limitations and implications.	2
3.	Development of IDM-basic principles.	1
4.	Biological disease management.	1
5.	Chemical disease management.	2
6.	Cultural disease management	2
7.	IDM in important crops – rice	2
8.	IDM – Wheat.	2
9.	IDM - Cotton	2
10.	IDM - Sugarcane.	2
11.	IDM – Chickpea.	2
12.	IDM - Rapeseed and mustard.	2
13.	IDM -Pearl millet	1
14.	IDM –Pulses	2
15.	IDM - Vegetable crops.	2
16.	IDM - Fruit.	2
17.	IDM - Plantation spice crops.	2
18.	IDM - Spice crops.	2
Total		**32**

Practical

Application of physical, biological and cultural methods, Use of chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM and multiple disease management in crops of regional importance as project work.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Application of physical methods their compatibility and integration in IDM.	2
2.	Application of biological methods their compatibility and	3

	integration in IDM.	
3.	Application of cultural methods their compatibility and integration in IDM.	3
4.	Use of chemical agents, their compatibility and integration in IDM.	3
5.	Use of biocontrol agents, their compatibility and integration in IDM.	2
6.	Demonstration of IDM and multiple disease management in crops of regional importance as project work.	3
Total		**16**

Suggested Readings:

1. *Gupta V.K. & Sharma R.C. (Eds). 1995. Integrated Disease Management and Plant Health. Scientific Publ., Jodhpur.*
2. *Mayee C.D, Manoharachary C, Tilak K.V.B.R., Mukadam D.S. & Deshpande Jayashree (Eds.). 2004. Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.*
3. *Sharma R.C. & Sharma J.N. (Eds). 1995. Integrated Plant Disease Management. Scientific Publ., Jodhpur.*

PPATH525POSTHARVESTDISEASES2(1+1)

Objectives

To acquaint with the post-harvest diseases of agricultural produce and their eco-friendly management

Theory

UNIT I

Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problems both by biotic and abiotic factors;

UNIT II

Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introducedantagonists.

UNIT III

Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards

UNIT IV

Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarious for each product and commodity. Physical and biological agents/practices responsible for development/ prevention of post-harvest diseases- traditional and improved practices

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures

1	Concept of post-harvest diseases, definitions, importance with reference to management and health.	3
2	Principles of plant disease management as pre- harvest and post-harvest.	2
3	Typesofpostharvestproblemsbothbybioticand abioticfactors.	2
4	Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens.	4
5	Factorsgoverningpostharvestproblemsbothasbioticand abiotic.	2
6	Roleof physical environment, agro-ecocystem leading to quiescent infection.	3
7	Pathogens and antagonist and their relationship, role of biocontrol agents.	2
8	Chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introducedantagonists.	3
9	Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents.	2
10	Control of aflatoxigenic and mycotoxigenic fungi.	2
11	Study of symptoms, toxicosis of various pathogens.	2
12	Knowledge of Codex Alimentarious for each product and commodity.	2
13	Physical and biological agents/practices responsible for development.	2
14	Prevention of post-harvest diseases- traditional and improved practices.	1
Total		**32**

Practical

Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens in vivo condition. Comparative efficacy of different fungicides and bioagents. Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers. Visit to coldstorage

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Isolation characterizationandmaintenanceofpost-harvest pathogens.	4
2.	Application of antagonists against pathogens in vivo condition.	4
3.	Comparative efficacy of different fungicides and bioagents.	4

4.	Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers.	3
5.	Visit to coldstorage.	1
Total		**16**

Suggested Readings

1. *PathakV N.1970.DiseasesofFruitCropsandtheirControl.IBHPubl., N Delhi.*
2. *Chaddha K L &Pareek O P. 1992. Advances in Horticulture Vol. IV, Malhotra Publ. House, New Delhi.*
3. *Agrios, G.N. 2014. Plant Pathology, 5th ed. Academic Press, New Delhi*

PPATH 531PLANT VIROLOGY3(2+1)

Objectives

To acquaint with the structure, virus- vector relationship, biology and management of plant viruses.

Theory

UNIT I

History and economic significances of plant viruses.General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions**.** Origin and evolution of viruses and their nomenclature andclassification.

UNIT II

Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatical changes. Transmission of viruses and virus-vector relationship.Isolation and purification of viruses.

UNIT III

Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.

UNIT IV

Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival). Management of diseases caused by plant viruses.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	History and economic significances of plant viruses.	3
2	General and morphological characters, composition and structure of viruses.	3
3	Myco-viruses, arbo- and baculo- viruses, satellite viruses, satellite RNAs, phages, viroids and prions**.**	2
4	Origin and evolution of viruses and their nomenclature andclassification.	3

5	Genome organization, replication in selected groups of plant viruses and their movement in host.	3
6	Response of the host to virus infection: biochemical, physiological, and symptomatical changes.	4
7	Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.	3
8	Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques.	3
9	Natural (R-genes) and engineering resistance to plant viruses.	4
10	Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival).	2
11	Management of diseases caused by plant viruses.	2
Total		**32**

Practical

Study of symptoms caused by plant viruses (followed by field visit). Isolation and biological purification of plant virus cultures. Bioassay of virus cultures on indicator plants and host differentials. Transmission of plant viruses (Mechanical, graft and vector and study of disease development). Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology. Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array & PCR based techniques. Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Claustal X/W, MEGA Software).

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Study of symptoms caused by plant viruses (followed by field visit).	1
2	Isolation and biological purification of plant virus cultures.	2
3	Bioassay of virus cultures on indicator plants and host differentials.	2
4	Transmission of plant viruses (Mechanical, graft and vector and study of disease development).	2
5	Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions).	2
6	Electron microscopy for studying viral particle morphology.	1
7	Antisera production, detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP) Later flow micro array & PCR based techniques.	3
8	Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software,	3

	Bioedit tool, Claustal X/W, MEGA Software).	
Total		**16**

Suggested Readings

1. *Biswas K.K. 2016. Plant Viruses, Diseases & their Management. I.K. International Publ. House, New Delhi*
2. *Bos L. 1964. Symptoms of Virus Diseases in Plants.Oxford & IBH., New Delhi.*
3. *Brunt A.A, Krabtree K, Dallwitz M.J, Gibbs A.J & Watson L. 1995.Virus of Plants: Descriptions and Lists from VIDE Database. CABI, Wallington.*
4. *Gibbs A & Harrison B. 1976. Plant Virology - The Principles. Edward Arnold, London.*
5. *Hull R. 2002. Mathew's Plant Virology. 4th Edn. Academic Press, New York.*
6. *Noordam D. 1973. Identification of Plant Viruses, Methods and Experiments.Oxford & IBH, New Delhi.*
7. *Walkey, D.G.A. 1991. Applied Plant Virology. II Edn. Chapman & Hall, London*
8. *Wilson C, 2014. Applied Plant Virology.CABI Publishing, England.*

PPATH 532 DISEASES OF FRUITS, VEGETABLES, PLANTATION AND ORNAMENTAL CROPS 3(2+1)

Objective

To acquaint with diseases of fruits, vegetables, plantation, ornamental plants and their management.

Theory

UNIT I

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, strawberry, citrus, mango, grapes, guava, ber, banana, papaya, fig, pomegranate, date palm, aonla and their management.

UNIT II

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, andcoconut and theirmanagement.

UNIT III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, marigold and their management.

UNIT IV

Symptoms and life cycle of pathogens. Factors affecting disease development of vegetable crop such as potato, onion, garlic, ginger, turmeric, carrot, radish, tomato, brinjal, pea, chilli, cucurbits, crucifers and leafy vegetables.

Lecture Schedule-Theory

S. No.	Topics	No. ofLecturers

1.	Diseases of apple, pear and strawberry.	3
2.	Diseases of citrus and mango.	2
3.	Diseases of grapes and guava.	2
4.	Diseases of ber, banana andpapaya.	3
5.	Diseases of fig and pomegranate.	2
6.	Diseases of date palm and aonla.	2
7.	Diseases of tea,coffee andcoconut.	2
8.	Diseases of roses, gladiolus and marigold.	2
9.	Diseases of potato and tomato.	2
10.	Diseases of onion, garlic.	2
11.	Diseases of ginger, turmeric.	2
12.	Diseases of carrot, radish.	2
13.	Diseases of brinjal, chili.	2
14. 3.	Diseases of cucurbits and crucifers.	2
15. 5.	Diseases of pea and leafy vegetables.	2
Total		**32**

Practical

Detailed study of symptoms and host parasite relationship of representative diseases of fruits, vegetables, plantation and ornamental crops. Collection and dry preservation of diseased specimens of important crops.

Lecture Schedule-Practical

S. No.	Topics	No. ofLecturers
1.	Study of symptoms and host parasite relationship of diseases of apple, pear and strawberry.	2
2.	Study of symptoms and host parasite relationship of diseases of citrus and mango.	1
3.	Study of symptoms and host parasite relationship of diseases of grapes and guava.	1
4.	Study of symptoms and host parasite relationship of diseases of ber, banana andpapaya.	1
5.	Study of symptoms and host parasite relationship of diseases of fig and pomegranate.	1
6.	Study of symptoms and host parasite relationship of diseases of date palm and aonla.	1
7.	Study of symptoms and host parasite relationship of diseases of tea, coffee andcoconut.	1
8.	Study of symptoms and host parasite relationship of diseases of roses, gladiolus and marigold.	1
9.	Study of symptoms and host parasite relationship of diseases of potato and tomato.	1
10.	Study of symptoms and host parasite relationship of diseases of onion, garlic.	1

11.	Study of symptoms and host parasite relationship of diseases of ginger, turmeric.	1
12.	Study of symptoms and host parasite relationship of diseases of carrot, radish.	1
13.	Study of symptoms and host parasite relationship of diseases of brinjal, chilli.	1
14. 3.	Study of symptoms and host parasite relationship of diseases of cucurbits, crucifers pea and leafy vegetables.	1
15.	Collection and dry preservation of diseased specimens of important crops.	1
Total		**16**

Suggested Readings

1. *Albajes R. Lodovica M. Vanlenteren J. C. and Elad Y. 2002 Integrated Pest and Disease Management in Greenhouse Crops. Kluwer Academic Publishers New York, Boston, Dordrecht, London, Moscow.*
2. *Chaube H.S, Singh U.S, Mukhopadhyay A.N & Kumar J. 1992. Plant Diseases of International Importance. Vol. II. Diseases of Vegetable and Oilseed Crops. Prentice Hall, Englewood Cliffs, New Jersey.*
3. *Gupta V.K. & Paul Y.S. 2001. Diseases of Vegetable Crops. Kalyani Publ., New Delhi.*
4. *Gupta V. K. & Sharma S. K. 2000 .Diseases of Fruit Crops. Kalyani Publ., New Delhi.*
5. *Mukerji K. G., 2004. Disease Management of Fruits and Vegetables. Kluwer Academic Publishers New York, Boston, Dordrecht, London, Moscow.*
6. *Pathak V. N. 1980. Diseases of Fruit Crops.Oxford & IBH, New Delhi.*
7. *Singh R. S. 2000. Diseases of Fruit Crops.Oxford & IBH, New Delhi.*
8. *Singh R.S. 1999. Diseases of Vegetable Crops. Oxford & IBH, New Delhi.*
9. *Gupta S.K & Thind T.S. 2006. Disease Problem in Vegetable Production. Scientific Publ., Jodhpur.*
10. *Walker J. C. 2004. Diseases of Vegetable Crops. TTPP, India.*

Ph.D. Programme

PPATH 611 ADVANCES IN VIROLOGY3(2+1)

Objectives

To educate about the advanced techniques and new developments in plant virology.

Theory

UNIT I

Origin, evolution and inter-relationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/strains: mutation, recombination, pseudo-recombination, component re-assortment etc.

UNIT II

Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology.

Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses.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.

UNIT III

Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/q PCR) and non PCR based: LAMP, Fluorescent in situ hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome- information content, coding and non-coding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.

UNIT IV

Gene expression, regulation and viral promoters.Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes.Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Origin, evolution and interrelationship with animal viruses.	1
2.	Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells.	2
3.	Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors.	2
4.	Terminologies used in immunology and serology.	1
5.	Classification, structure and functions of various domains of Immunoglobulins.	3
6.	Production of Polyclonal and monoclonal antibodies for detection of viruses.	2
7.	Immuno/serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay.	3
8.	Nucleic acid based assays for detection of plant viruses.	2
9.	Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/q PCR).	2
10.	Non PCR based: LAMP, Fluorescent in situ hybridization (FISH), dot blot hybridization.	2
11.	Plant virus genome organization (General properties of plant viral genome- information content, coding and non-coding	3

	regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.	
12.	Gene expression, regulation and viral promoters.	1
13.	Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes.	2
14.	Virus potential as vectors, genetically engineered resistance, transgenic plants.	2
15.	Techniques and application of tissue culture for production of virus free planting materials.	2
16.	Phylogenetic grouping system based on partial/complete sequences of virus genomes and using of next generation sequencing technology in plant virusdiscovery.	2
Total		**32**

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).

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Purification of viruses, SDS-PAGE for molecular weight determination.	2
2.	Production of polyclonal antiserum.	1
3.	Purification of IgG and conjugate preparation.	1
4.	Acquaintance with different serological techniques (i) DAC-ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA.	3
5.	Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation,and autoradiography.	2
6.	PCR application and viral genome cloning of PCR products.	2
7.	plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of	3

	viral sequences and phylogeny).	
8.	Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs).	2
Total		**16**

Suggested Readings

1. *Davies 1997. Molecular Plant Virology: Replication and Gene Expression. CRC Press, Florida. Fauquet et al. 2005.Vius Taxonomy. VIII Report of ICTV. Academic Press, New York.*
2. *Gibbs A & Harrison B. 1976.Plant Virology - The Principles. Edward Arnold, London.*
3. *Jones P, Jones PG & Sutton JM. 1997. Plant Molecular Biology: Essential Techniques. John Wiley & Sons, NewYork.*
4. *Khan J. A. &Dijkstra. 2002. Plant Viruses as Molecular Pathogens. Howarth Press, New York.*
5. *Maramorosch K, Murphy FA &Shatkin AJ. 1996. Advances in Virus Research. Vol. 46. Academic Press, NewYork.*
6. *Pirone T. P. & Shaw JG. 1990. Viral Genes and Plant Pathogenesis. Springer Verlag, New York.*
7. *Roger Hull 2002. Mathew's Plant Virology (4th Ed.). Academic Press, New York.*
8. *Thresh J. M. 2006. Advances in Virus Research Academic Press, New York.*

PPATH612MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION3(2+1)

Objectives

To understand the concepts of molecular biology and biotechnology in relation to host plant-pathogen interactions.

Theory

UNIT I

History of host plant resistance and importance to Agriculture.Importance and role of biotechnological tools in plant pathology.Basic concepts and principles to study host pathogen relationship.Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.

UNIT II

Different forms of plant-microbe interactions and nature of signals/effectors underpinning these interactions. Plant innate immunity: PAMP/DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

UNIT III

Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. 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. Gene for gene systems: Background, genetics,

phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitativeresistance.

UNIT IV

Pathogen population genetics and durability, virusesvs cellular pathogens.Gene deployment, cultivar mixtures. Disease emergence, host specialization.Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	History of host plant resistance and importance to Agriculture.	1
2.	Importance and role of biotechnological tools in plant pathology.	2
3.	Basic concepts and principles to study the host pathogen relationship.	2
4.	Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.	2
5.	Different forms of plant-microbe interactions and nature of signals/effectors underpinning these interactions.	2
6.	Plant innate immunity: PAMP/DAMP.	1
7.	Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes.	2
8.	recognition system.	1
9.	Signal transduction.	1
10.	Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing.	3
11.	Molecular basis of gene-for-gene hypothesis.	1
12.	R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes.	2
13.	Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles).	1
14.	Coevolution-arms race and trench warfare models.	1
15.	Meta populations, cost of resistance, cost of unnecessary virulence.	1
16.	GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.	1
17.	Pathogen population genetics and durability, viruses vs cellular	1

	pathogens.	
18.	Gene deployment, cultivar mixtures.	1
19.	Disease emergence, host specialization.	1
20.	Circadian clock genes in relation to innate immunity.	1
21.	Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches.	2
22	Different methods of gene transfer, biosafety issues related to GM crops.	2
Total		**32**

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.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Protein isolation.	1
2.	DNA isolation.	1
3.	RNA isolation.	1
4.	Plasmid extraction.	1
5.	PCR analysis.	2
6.	DNA electrophoresis.	2
7.	Protein electrophoresis.	2
8.	Bacterial transformation.	2
9.	Gene mapping and marker assisted selection.	2
10	Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.	2
Total		**16**

Suggested Readings

1. *Chet I. 1993.Biotechnology in Plant Disease Control.John Wiley & Sons, New York.*
2. *Gurr SJ, McPohersen MJ &Bowlos DJ.(Eds.).1992. Molecular Plant Pathology - A Practical Approach.Vols. I & II, Oxford Univ. Press,Oxford.*
3. *Aneja K.R. 2013. Laboratory manual of Microbiology & biotechnology. Scientific International Pvt. Ltd., New Delhi*
4. *Mathew JD. 2003. Molecular Plant Pathology. Bios Scientific Publ., UK.*
5. *R. Steffen and Sohn K. 2009. Host-Pathogen Methods and Protocols. Humana Press, a part of Springer Science+Business Media, LLC.*
6. *Ronald PC. 2007. Plant-Pathogen Interactions: Methods in Molecular Biology. Humana Press, NewJersey.*

7. *Stacey G & Keen TN. (Eds.). 1996. Plant Microbe Interactions. Vols. I-III. Chapman & Hall, New York; Vol. IV.APS Press, St. Paul, Minnesota.*

PPATH 621ADVANCES IN MYCOLOGY3(2+1)

Objectives

To acquaint with the advances in mycology

Theory

UNIT I

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy. Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.

UNIT II

Population biology, pathogenic variability/ vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi.Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

UNIT III

Ultra structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.

UNIT IV

Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nanoparticles - characterization process and application. Mycotoxins problems and it smanagement.

Lecture Schedule- Theory

S. No.	Topics	No. of Lectures
1.	General Introduction.	1
2.	Historical development and advances in mycology.	2
3.	Recent taxonomic criteria, morphological criteria for classification.	3
4.	Serological, chemical (Chemotaxonomy), molecular and numerical (Computer based assessment) taxonomy.	4
5.	Interaction between groups: Phylogeny.	2
6.	Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.	2
7.	Population biology, pathogenic variability/ vegetative compatibility.	2
8.	Heterokaryosis and parasexual cycle.	1
9.	Sex hormones in fungi.	1
10.	Pleomorphism and speciation in fungi.	1
11.	Mechanism of nuclear inheritance. Mechanism of extra-nuclear	1

	inheritance.	
12.	Biodegradation.	1
13.	Ultra structures and chemical constituents of fungal cells, functions of cell organelles.	2
14.	Mitosis, meiosis, gene action and regulation.	2
15.	Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.	2
16.	Genetic improvement of fungalstrains.	1
17.	Fungal biotechnology.	2
18.	Fungi mediated mycotoxins problems and itsmanagement.	2
Total		**32**

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 form different groups of fungi. Molecular characterization of fungi.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Isolation, purification and identification of cultures, spores and mating type determination.	2
2.	Study of conidiogenesis-Phialides, porospores, arthospores.	2
3.	Study of fruiting bodies in Ascomycotina.	1
4.	Identification of fungi up to species level.	3
5.	Study of hyphal anastomosis.	1
6.	Morphology of representative plant pathogenic genera from different groups of fungi.	4
7.	Molecular characterization of fungi.	3
Total		**16**

Suggested Readings

1. *Alexopoulos C.J, Mims C.W. & Blackwell M. 1996.Introductory Mycology. John Wiley & Sons, New York.*
2. *Dube H.C. 2005. An Introduction to Fungi. 3rd Edn. Vikas Publ. House, New Delhi.*
3. *Dube H.C. 2014. Modern Plant Pathology. 2nd Edn. Agrobios, Jodhpur, India*
4. *Kirk P.M, Cannon P.F, David J.C &Stalpers JA. (Eds.). 2001. Ainsworth and Bisby's Dictionary of Fungi. 9th Ed., CABI, Wallington.*
5. *Maheshwari R 2016. Fungi: Experimental Methods in Biology 2nd edn. CRC Press, U.S. Ulloa M & Hanlin RT. 2000.Illustrated Dictionary of Mycology.APS, St. Paul,*

Minnesota.Webster J & Weber R. 2007.Introduction to Fungi.Cambridge Univ. Press, Cambridge.

PPATH 622 ADVANCES IN PLANT PATHOGENIC PROKARYOTES3(2+1)

Objectives

To learn about the latest developments in all the plant pathogenic prokaryotes as a whole.

Theory

UNIT I

Prokaryotic cell: Molecular basis for **o**rigin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition **(bacteria)** cell wall/envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden Meyerhof pathway, Phosphoketolase Pathway and EntnerDoudoroff Pathway).

UNIT II

Current trends in taxonomy and identification of phytopathogenicprokarya**:** International code of nomenclature, Polyphasic approach, New / special detection methods for identification of bacterial plant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and Nomenclature.

UNIT III

Bacterial genetics**:** General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.

UNIT IV

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. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence**:** Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/hrc genes and TALE effectors. Synthesis and regulation of EPSs.

UNIT V

Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Prokaryotic cell: Molecular basis for **o**rigin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins.	2
2.	Flagella structure, assembly and regulation.	1
3.	Structure and composition **(bacteria)** cell wall/envelop.	1
4.	Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili).	1

5.	Bacterial chromosomes and plasmids, other cell organelles.	1
6.	Growth, nutrition and metabolism in prokaryotes (Embden Meyerhof pathway, Phosphoketolase Pathway and EntnerDoudoroff Pathway).	2
7.	Current trends in taxonomy and identification of phytopathogenic Prokarya**:** International code of nomenclature.	2
8.	Polyphasic approach, New / special detection methods for identification of bacterial plant pathogens.	1
9.	Taxonomic ranks hierarchy; Identification, Advances in classification and Nomenclature.	2
10.	Bacterial genetics**:** General mechanism of variability (mutation), specialized mechanisms of variability.	2
11.	Transposable genetic elements in bacteria-integron and prophages.	1
12.	Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.	2
13.	Bacteriophages: Composition, structure and infection.	1
14.	Classification and use of phages in plant pathology/bacteriology.	1
15.	Host pathogen interactions:	1
16.	Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker etc.	2
17.	Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing.	1
18.	Bacterial pathogenicity and virulence**:** Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls.	2
19.	Role of hrp/hrc genes and TALE effectors. Synthesis and regulation of EPSs.	2
20.	Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management.	1
21.	Endosymbionts for host defence.	1
22.	Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.	2
Total		**32**

Practical

Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteriausing species/pathovar specific primers. Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts. Important and emerging diseases and their managementstrategies

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Study on pathogenic race identification.	1
2.	Study on Plasmid profiling of bacteria.	1
3.	Study on Fatty acid profiling of bacteria .	2
4.	Study on RFLP profiling of bacteria and variability status.	1
5.	Study on endospore and Flagler staining.	2
6.	Test for secondary metabolite production, cyanides, EPS, siderophore.	2
7.	Specific detection of phytopathogenic bacteria using species/pathovar specific primers.	2
8.	Basic techniques in diagnostic kit development.	2
9.	Molecular tools to identify phytoendosymbionts.	2
10.	Important and emerging diseases and their managementstrategies.	1
Total		**16**

Suggested Readings

1. *Dale JW & Simon P. 2004. Molecular Genetics of Bacteria.John Wiley & Sons, New York.*
2. *Garrity GM, Krieg NR & Brenner DJ. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, NewYork.*
3. *Gnanamanickam SS. 2006. Plant-Associated Bacteria. Springer Verlag, New York.*
4. *Janse, J.D. 2005. Phytobacteriology: Principles & Practices. CABI Publishing, Willingford, UK.*
5. *Mount MS & Lacy GH. 1982. Plant Pathogenic Prokaryotes. Vols.I, II. Academic Press, New York. Sigee DC. 1993. Bacterial Plant Pathology: Cell and Molecular Aspects. Cambridge Univ. Press, Cambridge.*
6. *Punja Z.K. De Boer S.H. and Sanfaçon H. 2015. Plant Pathology Techniques and Protocols*
7. *Second Edition Christophe Lacomme Media New York.*
8. *Starr MP. 1992. The Prokaryotes. Vols.I – IV. Springer Verlag, New York.*

List of Journals

- *Annals of Applied Biology – Cambridge University Press,London*
- *Annals of Plant Protection Sciences- Society of Plant Protection, IARI, NewDelhi*
- *Annual Review of Phytopathology – Annual Reviews, Palo Alto,California*
- *Annual Review of Plant Pathology - Scientific Publishers,Jodhpur*
- *Canadian Journal of Plant Pathology - Canadian Phytopathological Society,Ottawa*
- *Indian Journal of Biotechnology - National Institute of Science Communication and Information Resources, CSIR, NewDelhi*
- *Indian Journal of Mycopathological Research- Indian Society of Mycology,Kolkata.*
- *Indian Journal of Plant Protection- PPAI, NBPGR,Hyderabad.*
- *Indian Journal of Virology - Indian Virological Society, New Delhi*
- *Indian Phytopathology-Indian Phytopathological Society, IARI NewDelhi.*
- *Journal of Mycology and Plant Pathology - ISMPP,Udaipur.*
- *JournalofPlantDiseaseScienceAssociationofPlantPathologists(CentralIndia) DKV,Akola.*

- *Journal of Phytopathology - Blackwell Verlag,Berlin*
- *Mycologia - New York Botanical Garden,Pennsylvania*
- *Mycological Research - Cambridge University Press,London*
- *Physiological Molecular Plant Pathology - Academic Press, London – Phytopathology - American Phytopathological Society,USA*
- *Plant Disease - The American Phytopathological Society,USA*
- *Plant Disease Research – Indian Society of Plant Pathologists,Ludhiana*
- *Plant Pathology - British Society for Plant Pathology, BlackwellPubl.*
- *Review of Plant Pathology - CAB International,Wallingford*
- *Virology- New York Academic Presse-Resources*
- *www.shopapspress.org*
- *www.apsjournals.apsnet.org*
- *www.apsnet.org/journals*
- *www.cabi_publishing.org*

PLANT PHYSIOLOGY

Semester Wise Distribution of Courses

S.No.	Course No.	Title	Credit Hrs.
M.Sc.(Ag.) Semester-I			
1	**PPHYS 511***	**PRINCIPLES OF PLANT PHYSIOLOGY-1: PLANT WATER RELATION AND MINERAL NUTRITION**	**3(2+1)**
2	**PPHYS 512***	**PRINCIPLES OF PLANT PHYSIOLOGY-II: METABOLIC PROCESS AND GROWTH REGULATION**	**3(2+1)**
3	**PPHYS 513**	**PHYSIOLOGY OF FIELD CROPS**	**2+0**
Minor Courses			
4	**GPB-514/GPB-513**	**VARIETAL DEVELOPMENT&MAINTENANCE BREEDING/SEED PRODUCTION AND CERTIFICATION**	**2(2+0)**
Supporting Course			
5	**STAT-511**	**STATISTICAL METHODS FOR APPLIED SCIENCES**	**3(2+1)**
Common Courses			

6	**PGS-511**	**LIBRARY AND INFORMATION SERVICES**	**1(0+1)**
Total			**14**
Semester-II			
1	**PPHYS 521**	**PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES**	**3(2+1)**
2	**PPHYS 522***	**PLANT DEVELOPMENT BIOLOGY: PHYSIOLOGICAL AND MOLECULAR BASIS**	**3(2+1)**
3	**PPHYS 523***	**SEED PHYSIOLOGY**	**3(2+1)**
Minor Courses			
4	**AGRON-521**	**MODERN CONCEPTS OF CROP PRODUCTION**	**3(3+0)**
Supporting Course			
5	**BIOCHEM-521**	**BASIC BIOCHEMISTRY**	**3 (2+1)**
Total			**15**
Semester –III			
1	**PPHYS 531**	**HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT**	**3 (2+1)**
2	**AGRON-531**	**AGRONOMY OF MAJOR CEREAL AND PULSES**	**3 (2+1)**
Common Courses			
3	**PGS -531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**

7	**PPHYS543**	**RESEARCH**	**30**
Semester-IV			
1	**PPHYS 541**	**SEMINAR**	**1(1+0)**
2	**PPHYS 542**	**COMPREHENSIVE**	**NC**
3	**PPHYS 543**	**RESEARCH**	**30**

***Core Courses**

PLANT PHYSIOLOGY

M.Sc.(Ag.) Programme

PPHYS 511* PRINCIPLE OF PLANT PHYSIOLOGY-I:PLANT WATER RELATION AND MINERAL NUTRITION 3(2+1)

Theory

Objectives

The course provides a basic knowledge on water and nutrient acquisition and their transport throughout the phenological stages. Further, it also provides hands on experience in assessing the plant and soil water status besides nutrient acquisition by plants.

BLOCK 1: PLANT WATER RELATIONS

Unit 1: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water, Concept of water potential; Plant cell and #soil water potential and their components; Methods to determine cell and #soil water potential; Concept of osmosis and diffusion, Soil physical properties and water availability in different soils; Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance

Unit 2: Water Absorption and Translocation

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins, Mycorrhizal association and its relevance in water mining

Unit 3: Transpiration and Evaporative Cooling

Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance, Energy balance: Solar energy input and output at crop canopy level, Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of

ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure, Antitranspirants and their relevance in agriculture

Unit 4: Water Productivity and Water Use Efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE

Unit 5: Moisture Stress and Plant Growth

Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level, Drought indices and drought tolerance strategies,Drought tolerance traits

BLOCK 2: MINERAL NUTRITION

Unit 1: Nutrient Elements and Their Importance

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients,Functions of mineral elements in plants**,** Deficiency and toxicity symptoms in plants

Unit 2: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; xylem and phloem mobility,Nutrient transport to grains at maturity, Strategies to acquire and transport minerals under deficient levels, Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition

Unit 3: Concept of Foliar Nutrition

Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Water and its importance; Molecular structureof water; Properties and functions ofwater, Conceptofosmosisanddiffusion,	2
2	Concept of water potential; Plant cell and soil water potential and their components;Methodstodeterminecellandsoilwaterpotential	2
3	Soil physical properties and water availability in different soils;	1
4	Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance	2
5	Root structure and functions; Root architecture and relevance in water mining;	1
6	Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins,Mycorrhizal association and its relevance in water mining	2
7	Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration, approaches to minimize evaporation and transpiration;	2
8	Concept of CCATD and its relevance, Energy balance: Solar energy input and output at crop canopy level.	1

9	Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing;Antitranspirants and their relevance in agriculture	2
10	Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure	2
11	WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measureWUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE	2
12	Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level, Drought indices and drought tolerance strategies, Drought tolerance traits	3
13	Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability;	2
14	Critical levels of nutrients, Functions of mineral elements in plants, Deficiency and toxicity symptoms in plants.	1
15	Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters;	2
16	Xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels	2
17	Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition	1
18	Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients	2
Total		**32**

Lecture schedule- Practical

S.No.	Topics	No. of Lectures
1	Standard solutions and preparation of different forms of solutions	2
2	Studies on the basic properties of water	1
3	Demonstration of surface tension of water and other solvents	1
4	Measurement of plant water status: Relative water content and rate of water loss	1
5	Determination of water potential through tissue volume and Chardakov's test	1
6	Determination of water potential using pressure bomb, osmometer, psychrometer	2

7	Determination of soil moisture content and soil water potential	1
8	Useofsoilmoistureprobesandsoilmoisturesensors	1
9	Measurement of transpiration rate in plants; use of porometry	1
10	Demonstration and use of anti-transpirants to reduce transpiration	1
11	Influence of potassium and ABA on stomatal opening and closing respectively	1
12	Deficiency and toxicity symptoms of nutrients	1
13	Effect of water stress on plant growth and development	1
14	Measurement of CCATD and its relevance	1
Total		**16**

Suggested readings

1. *Taiz T, Zeiger E and Max Mller IM, 2018, Fundamentals of Plant Physiology*
2. *Taiz L and Zeiger E. 2015. Plant Physiology and development.6th Ed*
3. *Salisbury FB and Ross C. 1992 (4th Ed.) Plant Physiology*
4. *Emanuel Epstein and Arnold J. Bloom.2004, Mineral nutrition of plants: principles and*
5. *perspectives.2nd Ed.*
6. *Hopkins WG and Huner NPA. 2004. Introduction to Plant Physiology*
7. *Kramer, P. J., Water relations of plants*
8. *Kirkham, M. B., Principles of soil and plant water relations*
9. *Hopkins WG, 2008, Introduction to Plant Physiology*

PPHYS-512* PRINCIPLE OF PLANT PHYSIOLOGY-II: METABOLIC PROCESS AND GROWTH REGULATION 3(2+1)

Objectives

This course will impart knowledge on cellular structure and function that determine of carbon and nitrogen metabolism, lipids, enzymes and secondary metabolites in plants. Relevance of metabolic processes on growth and development leading to productivity will be dealt.

Theory

BLOCK 1: Metabolic process and growth regulation

Unit 1: Carbon Metabolism – Photochemical Processes

Chloroplast ultrastructure with special mention of lamellar system, Excitation, electron and proton transfers and their relevance in energy conservation, Concepts of pigment systems and generation of powerful reductant and oxidant, Water oxidation, Water-water cycle and other aspects of electron transfer

Unit 2: Carbon Metabolism: Biochemical Processes

CO2 diffusion mechanisms and diffusive conductances, concept of Ci determining Photosynthesis,RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation ofCalvin cycle and metabolite fluxes, Photorespiration: the advantages and inefficiencies of photosynthesisbecause of photorespiration, Concepts of CO2 concentrating mechanisms (CCM) and spatial and temporal differences in carboxylation,Ecological aspects of C4and CAM photosynthesis, Product synthesis, Starch and Sucrose biosynthesis

Unit 3: Carbon Metabolism: Respiration

Mitochondrial organization and function, Aspects of Glycolysis, TCA cycle and mitETC, Relevance of growth and maintenance respiration, Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC

Unit 4: Product Synthesis and Translocation Leading to Crop Growth

Phloem loading and sugar transporting, concepts of bi-directional transport of sugars and other metabolites,Source-Sink relationship and modulation of photosynthesis, Concepts and definitions of Growth and Differentiation,Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAD

Unit 5: Nitrogen Assimilation and Protein Synthesis

Developments in d-nitrogen fixation, Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis,Inter-Dependence of carbon assimilation and nitrogen metabolisms

Unit 6: Lipid Metabolism and Secondary Metabolites

Storage, protective and structural lipids, Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids, Secondary metabolites and their significance in plant defense mechanisms.

Unit 7: Hormonal Regulation of Plant Growth and Development

Growth promoting and retarding hormones: biosynthesis, transport, conjugation, Mode of action of these hormones and their application in plant physiology

Unit 8: Synthetic Growth Promoters

Different synthetic hormones: Salicylic acid, strigolactones etc,,Roles and biological activities of various synthetic hormones, Commercial application of hormones to maximize growth and productivity

Unit 9: Morphogenesis and Reproductive Phase

Photoperiodism: Phytochromes, their structure and function, Circadian rhythms, Blue light receptors, Cryptochrome and morphogenesis,Vernalization and its relevance in germination

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Chloroplast ultrastructure with special mention of lamellar system; Excitation, electron and proton transfers and their relevance in energy conservation	2
2	Concepts of pigment systems and generation of powerful reductant and oxidant, Water oxidation, Water-water cycle and other aspects of electron transfer	2
3	CO_2 diffusion mechanisms and diffusive conductances, concept of Ci determining photosynthesis	1
4	RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycle and metabolite fluxes	2
5	Photorespiration: the advantages and inefficiencies of photosynthesis because of photorespiration	1
6	Concepts of CO_2 concentrating mechanisms (CCM) and spatial and temporal differences in carboxylation, Ecological aspects of $C_4$and CAM photosynthesis, Product synthesis, Starch and Sucrose biosynthesis	3

7	Mitochondrial organization and functions, Aspects of Glycolysis, TCA cycle and mitETC.	2
8	Relevance of growth and maintenance respiration, Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC	2
9	Phloem loading and sugar transporting, concepts of bi-directional transport of sugars and other metabolites	1
10.	Source-Sink relationship and modulation of photosynthesis	1
11	Concepts and definitions of Growth and Differentiation, Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAR	2
12	Developments in d-nitrogen fixation, Nitrate reduction and assimilation GS-GOGATprocess for amino acid synthesis,Inter-Dependence of carbon assimilation and nitrogen metabolisms	3
13	Storage, protective and structural lipids.	1
14	Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids.	2
15	Secondary metabolites and their significance in plant defense mechanisms.	1
16	Growth promoting and retarding hormones: biosynthesis, transport, conjugation, Mode of action of these hormones and their application in plant physiology.	2
17	Different synthetic hormones: Salicylic acid, strigolactones etc, Roles and biological activities of various synthetic hormones, Commercial application of hormones to maximize growth and productivity	2
18	Photoperiodism: Phytochromes, their structure and function Circadian rhythms, Blue light receptors: Cryptochrome and morphogenesis; Vernalization and its relevance in germination	2
Total		**32**

Lecture Schedule -Practical

S. No.	Topics	No. of Lectures
1	Radiant energy measurements	1
2	Separation and quantification of chlorophylls	1
3	Separation and quantification of carotenoids	1
4	O_2 evolution during photosynthesis	1
5	Anatomical identification of C3 and C4plants	1
6	Measurement of gas exchange parameters, conductance, photosyntheticrate, photorespiration	1

7	Measurement of respirationrates	1
8	Estimation of reducing sugars, starch	2
9	Estimation of NO3,free amino acids in the xylem exudates,quantification of soluble proteins	3
10	Bioassays for different growth hormones-Auxins,Gibberellins,Cytokinins,ABA and ethylene	3
11	Demonstration of photoperiodic responses of plants interms of flowering	1
Total		**16**

Suggested readings

1. *Plant Physiology, **Taiz**, Lincoln, **Zeiger**, Eduardo Origanl American edition published by Sinaue Associates, Inc., 2006; 4th ed., 2007, XXVI, ISBN: 978-3-8274-1865-4; © Springer.*
2. *Plant Physiologyby Frank Boyer Salisbury and Cleon Ross.Introduction to Plant Physiology 3e (Wie)byWilliamG.Hop*

PPHYS 513 PHYSIOLOGY OF FIELD CROPS2 (2+0)

Objectives

The objective is to impart comprehensive information on physiological processes and physiological basis of growth, development and productivity of field crop plants. Besides, the emphasis is on unique crop specific features.

Theory

Broad categories of crops that can be selected for this course are as follows.

1. Cereals – Rice, Wheat, etc.
2. Millets – Finger millet, Sorghum etc.
3. Pulse crops- Green, Chickpeas, Cowpea, etc.
4. Oilseed crops – Groundnut, Rapeseed Mustard, etc.

BLOCK 1: PHYSIOLOGY OF FIELD CROPS

Unit 1: **Introduction**

Origin- Variability in physiology of crop plants between wild species and cultivated. Adaptability to growing environments (ecosystems), Importance in food grain contribution

Unit 2: Crop Establishment, Crop Growth and Development

Seed characteristic features, dormancy, viability, concept of seed priming, seedling establishment and crop stand, Different crop growth stages, concept of source establishment and optimum LAI, Canopy architecture, light interception/radiation use efficiency, thermal time, heatunits, GDD, determining growth duration.

Unit 3: Reproductive Growth

Photo and thermo-periodic response for flowering, sink development, sink source relationship, partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years, structuring of ideal plant type, limitations to improve source to sink size, options to improve yield potential

Unit 4: Seed Nutrient Quality

Seed quality, seed as a source of nutrients, seed constituents and their improvement, concept of pathway engineering to improve seed quality

Unit 5: Plant Nutrition

Nutrient requirement, genetic variability in nutrient acquisition under constraint conditions, specific nutrient disorders

Unit 6: Abiotic Stress Response

Response to different abiotic stresses, plant traits/mechanics to improve adaptation to realize potential yields, Global warming responses, thermomorphogenesis, approaches to overcome the constraints.

Unit 7: Crop Specific Physiological Processes and Importance

Choosing location specific crop species exposure will be given on physiological process as described above. Besides, emphasis is on providing information on crop specific features/productivity constraints

Lecture Schedule -Theory

S.No.	Topics	No. of Lectures
1	Variability in physiology of crop plants between wild species and cultivated. Adaptability to growing environments (ecosystems), Importance in food grain contribution of major field crops	3
2	Seed characteristic features, dormancy, viability, concept of seed priming seedling establishment and crop stand of major field crops	4
3	Different crop growth stages, concept of source establishment and optimum LAI, Canopy architecture, light interception/radiation use efficiency, thermal time, heat units, GDD, determining growth duration of major field crops	5
4	Photo and thermo-periodic response for flowering, sink development, sink source relationship, partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years of major field crops	5
5	Structuring of ideal plant type, limitations to improve source to sink size, options to improve yield potential of major field crops	3
6	Seed quality, seed as a source of nutrients, seed constituents and their improvement, concept of pathway engineering to improve seed quality of major field crops.	3
7	Nutrient requirement, genetic variability in nutrient acquisition under constraint conditions, specific nutrient disorders of major field crops.	3
8	Response to different abiotic stresses, plant traits/mechanics to improve adaptation to realize potential yields of major field crops.	3
9	Global warming responses, thermo morphogenesis, approaches to overcome the constraints of major field crops.	3
Total		**32**

Suggested Readings

1. *Rinki, Mamrutha HM, Sareen Sindhu, Tiwari Vinod, Singh GP 2018. Dissecting the physiological and anatomical basis for high yield potential in HD 2967. Vegetos. 31:121-124*
2. *Kumar R, Kaur A, Ankita P, Mamrutha HM, Singh GP 2019. CRISPR based genome editing in wheat: A comprehensive review and future prospects. Molecular biology reports10.1007/s11033-019-04761-3*
3. *R.Tiwari and H.M.Mamrutha. 2014. Precision Phenotyping for Mapping of Traits for Abiotic Stress Tolerance in Crops. Biotechnology: Prospects and Applications. Editors. R.K. Salar, S.K. Gahlawat, P. Siwach and J.S. Duhan. Pp79-85. Publisher: Springer.*
4. *Wheat Physiological Breeding II: A Field Guide to Wheat Phenotyping. (CIMMYT publication).*
5. *Breeding for field crops book by David Allen Sleper and john Milton Poehlman.*
6. *Wheat Physiological Breeding volume I and II by Mathew Reynolds from (CIMMYT): Wheat Physiological Breeding: A Field Guide to Wheat Phenotyping.*
7. *Mamrutha H.M. et al. (2019) Physiological and Molecular Basis of Abiotic Stress Tolerance in Wheat. In: Rajpal V., Sehgal D., Kumar A., Raina S. (eds) Genetic Enhancement of Crops for Tolerance to Abiotic Stress: Mechanisms and Approaches, Vol. I. Sustainable Development and Biodiversity, vol 20. Springer, Cham.*
8. *Tiwari V. et al. (2017) Managing Abiotic Stresses in Wheat. In: Minhas P., Rane J., Pasala R. (eds) Abiotic Stress Management for Resilient Agriculture. Springer, Singapore.*

PPHYS 521 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES 3(2+1)

Objectives

This course aims to describe students the abiotic-stress physiology and their effects on plant growth and productivity. This will also help students gain insights into latest developments in stress physiology and stress tolerance mechanisms, approaches for crop improvement under stressful environment.

Theory

BLOCK 1: ABIOTIC STRESSES

Unit 1: Introduction to Abiotic Stresses

Abiotic stresses major constraints to realize potential yields of crop plants, yieldlosses,

Drought prone areas in India- Frequency of occurrence of drought, Rainfed Kharif, Rabi, areas affected by salinity, heavy metals, water logging, hightemperature scenario due to global warming.

BLOCK 2: DROUGHT STRESS

Unit 1: Moisture Stress Responses in Plants

Drought-characteristic features; water potential in the soil-plant-air continuum, Physiological and biochemical processes affected by drought.Oxidative stress- generation of ROS and other cytotoxic compounds, their effect on cellular process, Effect on total carbon gain- decrease in

photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.

Unit 2: Stress Perception and Molecular Responses of Plants to Drought Stress

Stress perception andsignal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms

Unit3:PlantAdaptiveMechanismstoDrought Escapeanddesiccationavoidancemechanism

Conceptofstressescape-exploitinggeneticvariabilityinphenology,Droughtavoidancemechanisms-Maintenanceofcellturgor,waterminingbyrootcharacters, Moistureconservation-Regulationoftranspiration-traitsreducingheatload,Stomatalfactorsguardcellmetabolism,moistureconservationbywaxes, Wateruseefficiency(WUE)andconceptofwaterproductivity-regulationoftranspirationefficiency-stomatalconductance,mesophyllefficiency,relevanceofWUEandPassioura'smodel.

Desiccationtolerance-Conceptofacquiredtolerance

Decreasedturgormediatedupregulationofcellulartolerancemechanisms,Osmolytes,managingcytotoxiccompounds,ROS,RCC,scavenging-enzymaticandnon-enzymatic,proteinturnover,stability,chaperones,membranestability,photo-protectionofchlorophylls.

Unit4:ApproachestoImproveDroughtTolerance

Developmentofgeneticresources-donorgenotypesforspecifictraits,Genomicresources- genes, QTL'sregulating adaptive mechanisms, Conventional, transgenicand molecular breedingapproaches to improverelevant adaptive traits,concept oftraitintrogression

BLOCK3:SALT,HEAVYMETAL,WATERLOGGING,TEMPERATUREANDLIGHTSTRESS

Unit1:SaltStress

Soil salinity-Effect of salt stress, ionic and osmotic effects; species variation in salttolerance;glycophytesandhalophytes,Salttolerancemechanisms-exclusion,extrusionandcompartmentalization,Signalingduringsaltstress–SOSpathway,Approachestoimprovesalt tolerance.

Unit2:HeavyMetalStressandWaterLogging

Heavymetaltoxicityinplants(eg.,Al,Cd),tolerancemechanismsandapproachestoimprove,Plant response to water logging, role of hormones- ethylene, mechanism of toleranceandapproachestoimprove.

Unit3:TemperatureandLightStress

High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes. High light and high ionizing radiation- photo oxidation and photo-inhibition; mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response (SAR)

Lecture Schedule -Theory

S.No.	Topics	No. of Lectures
1	Abiotic stresses, major constraints to realize potential yields of crop plants, yield losses.	1
2	Drought prone areas in India-Frequency of occurrence of drought, Rainfed- kharif, Rabi, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming.	2
3	Drought-characteristic features; water potential in the soil-plant-air continuum.	2
4	Physiological and biochemical processes affected by drought. Oxidative stress-generation of ROS and other cytotoxic compounds, their effect on cellular process.	2
5	Effect on total carbon gain-decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.	1
6	Stress perception and signal transduction leading to expression of regulatory genes, stress specific kinases, stress, specific transcription factors, functional genes associated with adaptive mechanisms	2
7	Concept of stress escape-exploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters.	2
8	Moisture conservation-Regulation of transpiration-traits reducing heat load, Stomatalfactors guard cell metabolism, moistureconservation by waxes	2
9	Water use efficiency (WUE) and concept of water productivity-regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model.	2
10.	Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoxic compounds, ROS, RCC, scavenging-enzymatic and non-enzymatic, protein turnover, stability, chaperones,membrane stability, photo-protection of chlorophylls.	2
11	Development of genetic resources-donor genotypes for specific traits, Genomic resources-genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression	2
12	Soil salinity-Effect of salt stress, ionic and osmotic effects; species variation in salt tolerance; glycophytes and halophytes, Salttolerance mechanisms-exclusion, extrusion and compartmentalization, Signaling during salt stress–SOS pathway, Approaches to improve salt tolerance	4
13	Heavy metal toxicity in plants (eg., Al, Cd), tolerance	2

	mechanisms and approaches to improve.	
14	Plant response to water logging, role of hormones-ethylene, mechanism of tolerance and approaches to improve.	2
15	High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes.	2
16	High light and high ionizing radiation-photo oxidation and photo-inhibition; mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response (SAR)	2
Total		**32**

Lecture Schedule- Practical

S.No.	Topics	No. of Lectures
1	Soil and plant water status	1
2	Drought stress imposition and measurement of physiological and biochemical changes in plants under stress–gas exchange and fluorescence measurements**.**	1
3	Determination of water use efficiency as a drought resistant trait**.**	1
4	Drought Susceptibility Index (DSI) -precise field technique to identifyproductive genotypes under stress.	1
5	Approaches to quantify root characters	1
6	Determination of stomatal parameters and canopy temperature as a reflection of transpiration and root activity	1
7.	Determination of Salinity Tolerance Index.	1
8.	Studying acclimation response - Temperature induction response	1
9.	Heat tolerance and membrane integrity- Sullivans heat tolerance test.	1
10.	Quantification of osmolytes – proline under stress.	1
11.	Oxidative stress imposition- Quantification of oxidative stress	1
12.	Quantification of ROS under stress.	1
13.	Estimation of ABA content in leaf and root tissues under stress.	1
14.	Determination of Sodium and Potassium in plant tissue grown under salt stress.	1
15.	Estimation of antioxidant enzymes.	2
Total		**16**

Suggested Readings

1. *Plant physiology Book by Frank B. Salisbury, Cleon W. Ross.*
2. *Plant Physiology Book by Eduardo Zeiger and Lincoln Taiz.*
3. *Pereira A (2016) Plant Abiotic Stress Challenges from the Changing Environment. Front. Plant Sci. 7:1123. doi: 10.3389/fpls.2016.01123*
4. *Sergey Shabala, 2012. Plant Stress Physiology.*

PPHYS 522 PLANT DEVELOPMENTAL BIOLOGY: PHYSIOLOGICAL AND MOLECULAR BASIS 3(2+1)

Objectives

To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

Theory

BLOCK 1: PLANT DEVELOPMENTAL BIOLOGY

Unit 1: Evolutionary Development of Plants and Role of Environment

Plant development and plasticity, evolution, Biodiversity, Novel features of plant growth and development, Concept of plasticity-evolution and biodiversity, Model plants for study; Environment and development, Developmental stages and program; Cell-cycle, totipotency and regeneration.

Unit 2: Physiological and Molecular Determinants of Seed Biology

Seed development- Physiology of seed development, role of hormones in embryo development; seed development and maturation, Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation. Seed germination- seed structure and Hormonal regulation of germination, Mobilization of food reserves during seed germination.

Unit 3: Vegetative Growth and Organ Development

Regeneration and totipotency-organ differentiation and development–role of hormones-developmental control genes in crop plants,Meristems in plant development, Shoot, Leaf, Trichome and stomate development and differentiation, Axillary shoot branching; Bud dormancy and growth, Root development; Nodule development; Tuber development- hormonal control, signaling and molecular regulation-genes involved,Vascular bundle development-xylem and phloem differentiation

Unit 4: Physiological and Molecular Aspects of Reproductive Growth and Development

Floral Induction and Development: Molecular and physiological mechanism of transition-vegetative to reproductive phase- floral organ initiation and development their controls, Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction, Pollen germination and tube growth, role of imprinting, Male sterility, and fertility restoration; Self incompatibility, Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects, Sex determination in plants, mate choice in plants, Embryo and endosperm development-fertilization, role of imprinting; Parthenocarpy and apomixes

Unit 5: Ripening and Senescence

Fruit development, enlargement, maturation and ripening; climacteric and non- climacteric fruit, ripening mechanism, Hormonal, biochemical & Molecular aspects of fruit ripeningSenescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

Unit 6: Physiological and Molecular Regulation of Plant Development Influenced by Light and Temperature

Light control of plant development: Phytochromes and cryptochromes, phototropins, their structure, biochemical properties and cellular distribution, Molecularmechanismsoflightperception,signaltransductionandgeneregulation,Photoperiodismanditssign

ificance,vernalizationandhormonalcontrol,Circadianrhythms-
biologicalclocksandtheirgeneticandmoleculardeterminants,Thermomorphogenesis-Thermoperiodism

BLOCK2: APPLICATION OF MORPHOGENESISAND ITS PRACTICAL APPLICATION

Unit 7: Tissue culture and micro-propagation

Applications of tissue culture for plant production, callus induction, somatic embryogenesis, regeneration from different explants, Micro-propogation, tip and axillary node culture of commercially important crops, hardening and ex-vitro establishment, concept of somatic hybridization and protoplast culture.

Unit 8: Application of in-vitro techniques for crop improvement, Development of somaclones, identification and exploitation of somaclonal variants,Haploid production, pollen/anther, ovule/ovary culture,Production of secondary metabolites by tissue culture, concept of bio-fermenters,Plant transformation, development of transgenic plants and their characterization,Germplasm storage, cryopreservation and regulation.

Lecture Schedule -Theory

S.No.	Topics	No. of Lectures
1	Plant development and plasticity, evolution, Biodiversity	1
2	Novel features of plant growth and development, Concept of plasticity-evolution and biodiversity, Model plants for study; Environment and development.	2
3	Developmental stages and program; Cell-cycle, totipotency and regeneration.	1
4	Seed development- Physiology of seed development, role of hormones in embryo development; seed development and maturation.	1
5	Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation. Seed germination- seed structure and Hormonal regulation of germination, Mobilization of food reserves during seed germination.	2
6	Regeneration and totipotency- organ differentiation and development – role of hormones- developmental control genes in crop plants.	1
7	Axillary shoot branching; Bud dormancy and growth, Shoot, Leaf, Trichome and stomate development and differentiation. Meristems in plant development.	2
8	Root development; Nodule development; Tuber development-hormonal control, signaling and molecular regulation- genes involved.Vascular bundle development- xylem and phloem differentiation	1
9	Floral Induction and Development: Molecular and physiological mechanism of transition -vegetative to	1

	reproductive phase- floral organ initiation and development their controls	
10	Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction- Pollen germination and tube growth; role of imprinting; Male sterility: and fertility restoration; Self incompatibility; Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects	1
11	Sex determination in plants, mate choice in plants	1
12	Embryo and endosperm development- fertilization, role of imprinting; Parthenocarpy and apomixes	1
13	Fruit development, enlargement, maturation and ripening; climacteric and nonclimacteric fruit ripening mechanism	1
14	Hormonal, biochemical & Molecular aspects of fruit ripening	1
15	Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.	1
16	Light control of plant development: Phytochromes and cryptochromes, phototropins, their structure, biochemical properties and cellular distribution	1
17	Molecular mechanisms of light perception, signal transduction and gene regulation	1
18	Thermomorphogenesis- Thermoperiodism, Circadian rhythms-biological clocks and their genetic and molecular determinants Photoperiodism and its significance, vernalization and hormonal control	3
19	Applications of tissue culture for plant production, callus induction, somatic embryogenesis, regeneration from different explants	2
20	Micro-propogation, tip and axillary node culture of commercially important crops, hardening and ex-vitro establishment, concept of somatic hybridization and protoplast culture.	2
21	Haploid production, pollen/anther, ovule/ovary culture,Development of somaclones, identification and exploitation of somaclonal variants	2
22	Germplasm storage, cryopreservation and regulation, Plant transformation, development of transgenic plants and their characterization, Production of secondary metabolites by tissue culture, concept of bio-fermenters.	3
Total		**32**

Lecture Schedule -Practical

S.No.	Topics	No. of Lectures

1	Studying shoot apical meristem, floral meristem development and pollen tube development	1
2	Phenotyping photomorphogenesis: a) Studying effect of day length (short day and long day) in regulating floral induction/ flowering time in short day/long day/day neutral plants and b) effect of light on seed germination in light-sensitive and -insensitive seeds.	2
3	Studying effect of temperature on- a) thermomorphogenesis- measuring hypocotyl elongation under different temperature conditions and b) sex determination using cucurbits/sesame plants	1
4	Measure physiological paramters of fruit ripening and study the expression of key genes regulating ripening.	1
5	Study the effect of ethylene, its inhbibitor and scruber on ripening (tomato).	1
6	Study different sterilization techniques, prepare media stocks and plant hormones.	1
7	Inoculate explant (seed and leaf tissue) of model plant for callus induction	1
8	Subculture the callus and standardize regeneration protocol for shoot and root induction using callus and leaf explant.	1
9	Micro-propagation using meristem tip and axillary node culture.	1
10.	Standardize anther/ pollen culture for haploid production in model/crop/horticultural plant.	1
11	Isolation of protoplast from Arabidopsis/tobacco and its culturing	1
12	Study about selectable marker, reporter gene, PCR, southern and northern blotting techniques.	1
13	Transformation of tobacco callus or leaf explant by Agrobacteriumtumefacines and Agrobacterium rhizogenes for production of transgenic	1
14.	Molecular characterization of transgenic- PCR, southern blotting, gene expression.	1
Total		**16**

Suggested Readings

1. *B. Bahadur et al. (eds.), Plant Biology and Biotechnology: Volume I: Plant*
2. *Karl J. Niklas. Plant Evolution- An Introduction to the History of Life. Diversity, Organization, Function and Improvement*
3. *J. Derek Bewley et al., Seeds-Physiology of Development, Germination and Dormancy.*
4. *John R. Pannel. (2017). Plant Sex Determination. Current Biology 27, R191–R197.*
5. *Howard Thomas (2013). Senescence, ageing and death of the whole plant. New*

Phytologist. 197: 696–711

6. *Mieke de Wit (2016). Light-Mediated Hormonal Regulation of Plant Growth and Development. Annu. Rev. Plant Biol. 67: 22.1–22.25*
7. *Bhojwani SS and Razdan MK. Plant tissue culture: theory and practice, a revised edition. Elsiver publication.*
8. *Krishna, H., Alizadeh, M., Singh, D., Singh, U., Chauhan, N., Eftekhari, M., and Sadh, R. K. (2016). Somaclonal variations and their applications in horticultural crops improvement. 3 Biotech, 6(1), 54*

PPHYS 523* SEED PHYSIOLOGY3(2+1)

Objectives

This course will approach the subjects from two perspectives –physiology of seed development and seed germination. It aims to describe students the physiological processes involved in regulation and mechanism of seed development, dormancy and germination.

Theory

BLOCK 1: PHYSIOLOGY OF SEED DEVELOPMENT

Unit 1: Introduction to Seed Physiology

Importance of seed as a propagule, seed structure and functions, chemical composition of seeds. Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction, pollen load hypothesis; genetical and environmental influence on seed development, Source-Sink relationship affecting seed yield and quality,Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds

Unit 2: Seed Development

Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changesduring seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development

Unit 3: Seed Maturation

Seed maturation and maturation indices; physiological and anatomical changes during seed maturation;Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance; role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying,Seed abortion and approaches to reduce it.

Unit 4: Metabolism in Developing Seed

Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds, Seed respiration and mitochondrial activity; seed respiration rate and storability of seeds, Seed ageing, Mobilization of stored resource in seeds; Chemistry of oxidation of starch, proteins and fats; Utilization of breakdown products by embryonic axis.

BLOCK 2: PHYSIOLOGY OF SEED GERMINATION AND DORMANCY

Unit1: Seed germination

Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination: seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seed, Environmental regulation of germination:

hydro-time, thermal time and hydrothermal time models; Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination.

Unit 2 :Seed Dormancy and Viability

Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments; Ecological perspective of seed dormancy,

Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodox and recalcitrant seeds, Seed vigour: concept, importance, measurement; Physiological, biochemical and molecular basis of seed vigour

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Importance of seed as a propagule, seed structure and functions; chemical composition of seeds. Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development**.**	2
2	Source-Sink relationship affecting seed yield and quality	2
3	Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds	1
4	Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seed germination	2
5	Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changes during seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development	4
6	Seed maturation and maturation indices; physiological and anatomical changes during seed maturation	1
7	Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance; role of ABA LEA’s, HSP’s, dehydrins and other stress proteins during seed maturation and drying,	2
8	Seed abortion and approaches to reduce it.	1
9	Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds.	2
10	Seed respiration and mitochondrial activity; seed respiration rate and storability of seeds.	2

11	Seed ageing, Mobilization of stored resource in seeds; Chemistry of oxidation of starch, proteins and fats; Utilization of breakdown products by embryonic axis.	2
12	Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination: seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seed.	3
13	Environmental regulation of germination: hydro-time, thermal time and hydrothermal time models; Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination.	2
14	Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments; Ecological perspective of seed dormancy.	2
15	Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodox and recalcitrant seeds	2
16	Seed vigour: concept, importance, measurement; Physiological, biochemical and molecular basis of seed vigour	2
Total		**32**

Lecture Schedule -Practical

S.No.	Topics	No. of Lectures
1	Determination of seed reserves: carbohydrates, proteins and lipids	1
2	Study of different seed structures	1
3	Kinetics of seed imbibition; Seed germination test, enzymatic activities and respiration during germination and vigour testing methods etc.	1
4	Accelerated ageing test to know the seed vigour and storability	1
5	Measurement of seed moisture content	1
6	Determination of amylase activity in germinating seeds	1
7	Measurement of electrical conductivity in seed leachates	1
8	Measurement of seed viability using tetrazolium chloride	1
9	Determination of dehydrogenase activity	2
10	Seed germination study-Determination of Germination Index and seedling growth	1
11	Measurement ofseed vigour index	1

12	Dormancy breaking treatments	1
13	Seed priming techniques	1
14	Effect of environmental stresses on seed germination and seedling growth	1
15	Effect of hormones on seed germination	1
Total		**16**

Suggested Readings

1. *Bewley, JD, Bradford K,,Hilhorst H, Nonogaki H. (2013). Seeds: Physiology of Development, Germination and Dormancy, Springer-Verlag*
2. *Larkins BA and Vasil IK (Ed), Cellular and Molecular Biology of Plant Seed Development, 2010, Springer*
3. *Vanangamudi K, Natarajan K and Vanangamudi M, Seed Physiology, Associated Publishing Company*
4. *Bewley JD and Black M, 1994 Seeds: Physiology of Development and Germination, Springer*
5. *N.W. Pammenter and Patricia Berjak (2000). Aspects of recalcitrant seed physiology. R.Bras. Fisiol. Veg., 12: 56-69.*
6. *Prakash. M. 2011. Seed physiology of crops.(ed). Satish Serial Publishing house, New Delhi.*
7. *Roberto Benech-Arnold, Rodolfo Sanchez. 2004. Handbook of Seed Physiology: Applications to Agriculture. CRC Press .*
8. *Vijayakumar, A. 2001. Seed Dormancy an overview. In : Recent techniques and Participatory Approaches in Quality seed production (eds. K. Vanangamudiet al.,) TNAU, Coimbatore. pp 287-396.*
9. *Padmavathi, S., M. Prakash, S. Ezhil Kumar, G. Sathianarayanan and A.Kamaraj. 2012. A Text Book of Seed Science and Technology. New India Publishing Agency, New Delhi.*
10. *Tina Steinbrecher Gerhard Leubner-Metzger (2017). The biomechanics of seed germination. Journal of Experimental Botany, 68(4): 765–783.*
11. *Bench ALR and Sanchez RA. 2004. Handbook of Seed Physiology. Food Product Press.*

PPHYS 531 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT 3(2+1)

Objectives

It provides knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signaling and the role in regulating basic physiological processes governing developmental events in plants.

Theory

BLOCK 1: PLANT GROWTH AND DEVELOPMENT: HORMONAL REGULATION

Unit 1: Introduction to Plant Hormones

Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances:Classical hormones, Definition and classification

of growth regulating substances:Endogenous growth substances other than hormones, Synthetic chemicals

Unit 2: Plant Hormones - Discovery and Metabolism

Discovery, biosynthetic pathways and metabolism of Auxin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Abscisic acid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones

Unit 3: Physiological Role of Hormones in Plant Growth and Development

Physiological functions of Auxin and use of mutants and transgenic plants ineludicating the physiological functions, Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions,Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Abscisic acid and use of mutants and transgenic plantsin elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants ineludicating the physiological functions, Physiological functions of Brassinosteroidsand Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways, metabolism and physiological roles of Salicylicacid and Peptide hormones

Unit 4: Endogenous Growth Substances other than Hormones

Discovery, biosynthetic pathways, metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways, metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways, metabolism and physiological roles of systemins, Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level

Unit 5: Hormone Signaling

Hormone signal perception, transduction - Receptors, components andmechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components andmechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones

Unit 6: Key Genes Regulating Hormone Levels and Functions

Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies

Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

Crosstalk of Hormones in Regulation of Plant Growth and DevelopmentProcesses: Floral transition, reproductive development, Shoot and root apical meristem development

Unit 8: Practical Utility of Growth Regulators in Agriculture and Horticulture

Practical Utility of Growth Regulators in Agriculture and Horticulture:Rooting of cuttings, Vine and brewing industry, Promotion of gynoeciousflowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Growth, differentiation and development regulated by plant growth substances	1
2	Definition and classification of growth regulating substances:Classical hormones	1
3	Definition and classification of growth regulating substances:Endogenous growth substances other than hormones, Synthetic chemicals	1
4	Discovery, biosynthetic pathways and metabolism of Auxins	1
5	Discovery, biosynthetic pathways and metabolism of Gibberellins	1
6	Discovery, biosynthetic pathways and metabolism of Cytokinins	1
7	Discovery, biosynthetic pathways and metabolism of Abscisic acid	1
8	Discovery, biosynthetic pathways and metabolism of Ethylene	1
9	Discovery, biosynthetic pathways and metabolism of Brassinosteroids	1
10	Discovery, biosynthetic pathways and metabolism of Strigolactones	1
11	Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions	1
12	Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions	1
13	Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions	1
14	Physiological functions of Abscisic acid and use of mutants and transgenic plants in elucidating the physiological functions	1
15	Physiological functions of Ethylene and use of mutants	1

	and transgenic plants in elucidating the physiological functions	
16	Physiological functions of Brassinosteroidsand Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions	1
17	Discovery, biosynthetic pathways, metabolism and physiological roles of Salicylic acid and Peptide hormones	1
18	Discovery, biosynthetic pathways, metabolism and physiological role of Polyamines and Karrikins	1
19	Discovery, biosynthetic pathways, metabolism and physiological roles of Jasmonates and Tricontanol	1
20	Discovery, biosynthetic pathways, metabolism and physiological roles of systemins, Concept of death hormone	1
21	Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level	1
22	Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level	1
23	Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid)	1
24	Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones)	1
25	Advances in elucidating the structure and function of receptors and signaling components of important hormones	1
26	Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies	1
27	Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development	2
28	Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits	2

29	Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop	2
Total		**32**

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Extraction of Auxins from plant tissue	1
2	Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique	2
3	Bioassay of auxin- effect on rooting of cuttings	1
4	Extraction of abscisic acid (ABA) from plant tissue	1
5	Separation and detection of ABA by HPLC/Immunological technique	1
6	ABA bioassays- effect on stomatal movement	1
7	Preparation of samples for ethylene estimation in plant tissue	1
8	Estimation of ethylene in plant tissues using gas chromatography	1
9	Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut	1
10.	Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC	1
11	Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique	1
12	GA bioassays- effect on germination of dormant seeds	1
13	Cytokinin- extraction from plant tissue	1
14	Separation and detection of cytokinin by GC / GC-MS / HPLC	1
15	Cytokinin bioassays- effect on apical dominance and senescence / stay green	1
Total		**16**

Suggested Readings

1. *Davies, P.J. 2004, Plant Hormones: Biosynthesis, Signal Transduction and Action, 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.*
2. *Hedden, P. and Thomas, S.J. 2006. Plant Hormone Signalling, Blackwell Publishing Ltd., Oxford, UK.*
3. *Osborne, D.J. and McManus, M.T. 2005. Hormones, Signals and Target Cells in Plant Development. Cambridge University Press, New York, USA.*
4. *Tucker, G.A. and Roberts, J.A. 2000. Plant Hormone Protocols. Humana PressSpringer*

Science, New York, USA

5. *Buchanan B B, Gruissem W and Jones R L Biochemistry and Molecular biology of Plants, 2nd Edition*
6. *The Arabidopsis Book(http://www.arabidopsisboo*
7. *Teaching Tools in Plant Biology, The American Society of Plant Biologists*
8. *Lincoln Taiz and Eduardo Zeiger. Plant Physiology and Development, 6th Edition.*

SOIL SCIENCE

Semester Wise Distribution of Courses

S. No.	Course No.	Title	Credit Hrs

M.Sc.(Ag.)			
Semester-I			
1	***SOIL 511**	**SOILCHEMISTRY**	**3(2+1)**
2	***SOIL512**	**SOILMINERALOGY,GENESISANDCLASSIFICATION**	**3(2+1)**
3	**SOIL 513**	**ANALYTICAL TECHNIQUE AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS**	**2(0+2)**
Minor courses			
4	**AGRON-513**	**PRINCIPLES AND PRACTICES OF ORGANIC FARMING**	**2(1+1)**
Supporting Courses			
5	**STAT-511**	**STATISTICAL METODS FOR APPLIED SEIENCES**	**3(2+1)**
Common Courses			
6	**PGS-511**	**LIBRARY AND INFORMATION SERVICES**	**1(0+1)**
Total			**14**
Semester- II			
1	***SOIL521**	**SOILFERTILITYANDFERTILIZERUSE**	**3(2+1)**
2	**SOIL522**	**SOILBIOLOGYANDBIOCHEMISTRY**	**3(2+1)**
3	**SOIL523**	**MANAGEMENTOFPROBLEMATICSOILSANDWATER**	**3(2+1)**
Minor Courses			
4	**PPHYS-521**	**PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES**	**3(2+1)**
Supporting Courses			
5	**STAT-521**	**EXPERIMENTAL DESIGN**	**3(2+1)**
Total			**15**
Semester -III			
1	***SOIL531**	**SOILPHYSICS**	**3(2+1)**
Minor Courses			
2	**PPHYS-531**	**HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT**	**3(2+1)**
Common Courses			
3	**PGS - 531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
7	**SOIL**	**RESEARCH**	**30**

	543		
Semester- IV			
1	SOIL 541	SEMINAR	1(0+1)
2	SOIL 542	COMPREHENSIVE	NC
3	SOIL 543	RESEARCH	30
Non Core Courses			
	Course No.	Title	Credit Hours
1	SOIL505	SOILEROSIONANDCONSERVATION	3(2+1)
2	SOIL507	RADIOISOTOPESINSOILANDPLANTSTUDIES	2(1+1)
3	SOIL508	SOIL,WATERANDAIRPOLLUTION	3(2+1)
4	SOIL509	REMOTESENSINGANDGISTECHNIQUEFORSOILANDCROPSTUDIES	3(2+1)
5	SOIL514	INTRODUCTIONTONANOTECHNOLOGY	3(2+1)
6	SOIL515	LANDDEGRADATIONANDRESTORATION	1(1+0)
7	SOIL516	SOILSURVEYANDLANDUSEPLANNING	3(2+1)
Ph.D. Semester-I			
1	*SOIL611	PHYSICAL CHEMISTRY OF SOIL	2(2+0)
2	*SOIL612	SOIL GENESIS AND MICRO MORPHOLOGY	2(2+0)
3	SOIL 613	RECENT TRENDS IN SOIL PHYSICS	2(2+0)
Minor Courses			
4	AGRON-512/ AGRON-511	PRINCIPLES AND PRACTICES OF SOIL FERTILITY&NUTRIENT MANAGEMENT/PRINCIPLES AND PRACTICES OF WATER MANAGEMENT	3(2+1)
Supporting Courses			
5	PPHYS-513	PHYSIOLOGY OF FIELD CROPS	2(2+0)
Total			11

Semester-II			
1	**SOIL 621**	**MODERN CONCEPT IN SOIL FERTILITY**	**2(2+0)**
2	**SOIL622**	**BIO-CHEMISTRY OF SOIL ORGANIC MATTER**	**2(2+0)**
3	**SOIL 623**	**SOIL RESOURCE MANAGEMENT**	**2(2+0)**
Minor Courses			
4	**PPHYS-523/ PPHYS-522**	**SEED PHYSIOLOGY/PLANT DEVELOPMENT BIOLOGY:PHYSIOLOGICAL AND MOLECULAR BASIS**	**3(2+1)**
Supporting Courses			
5	**AGRON -521/ AGRON -522**	**MODERN CONCEPTS IN CROP PRODUCTION/PRINCIPLES AND PRACTICES OF WEED MANAGEMENT**	**3(2+1)**
Total			**12**
Semester –III and onward			
1	**SOIL 641**	**DOCTORAL SEMINAR I**	**1 (1+0)**
2	**SOIL 642**	**DOCTORAL SEMINAR II**	**1 (1+0)**
3	**SOIL 643**	**COMPREHENSIVE**	**NC**
4	**SOIL 644**	**DOCTORAL RESEARCH**	**75**
Non Core Courses (Ph.D.)			
1	**SOIL607**	**MODELLING OF SOIL PLANT SYSTEM**	**2(2+0)**
2	**SOIL608**	**CLAY MINERALOGY**	**3(2+1)**
3	**SOIL609**	**RECENT TRENDS IN SOIL MICROBIAL BIODIVERSITY**	**3(2+1)**

Non core courses adopted and approved in BoS,out of which one or more courses may be opted in future as and when need arises in future

M.Sc. Programme

SOIL 511 SOILCHEMISTRY 3 (2+1)

Objectives

Tointroducetheclassicalconceptsofsoilchemistryandtofamiliarizestudentswithmoderndevelopmentsinchemistryofsoilsinrelationtousingsoilsasamediumforplantgrowth.

Theory

UnitI

Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

UnitII

Elementsofequilibriumthermodynamics,chemicalequilibria,electrochemistryandchemicalkinetics.

UnitIII

Soilcolloids:inorganicandorganiccolloids-originofcharge,conceptofpointofzero-charge(PZC)anditsdependenceonvariable-chargesoilcomponents,surfacechargecharacteristicsofsoils;diffusedoublelayertheoriesofsoilcolloids,zetapotential,stability,coagulation/flocculationandpeptizationofsoilcolloids;electrometricpropertiesofsoilcolloids;sorptionpropertiesofsoilcolloids;soilorganicmatter-fractionationofsoilorganicmatteranddifferentfractions,CharacterizationofOM;clay-organicinteractions.

UnitIV

Ion exchange processes in soil; cation exchange- theories based on law of mass action(Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms,Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activitymeasurement,thermodynamics,statisticalmechanics;anionandligandexchange- inner sphereandouter-spheresurfacecomplexformation,fixationofoxy-anions, hysteresis insorption-

desorptionofoxy-anionsandanions,shiftofPZConligandexchange,AEC,CEC;experimental methodstostudyionexchangephenomenaandpracticalimplicationsinplantnutrition.

UnitV

Potassium,phosphateandammoniumfixationinsoilscoveringspecific andnon-specific sorption; precipitation-dissolution equilibria; Concept of quantity/intensity (Q/I) relationship;stepandconstant-rateK;management aspects.

UnitVI

Chemistryofacidsoils;activeandpotentialacidity;limepotential,chemistryofacidsoils;sub-soilacidity.

UnitVII

Chemistryofsalt-affectedsoilsandamendments;soilpH,ECe,ESP,SARandimportantrelations;soilmanagement andamendments.

UnitVIII

Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients,environmentalsoilchemistry.

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1.	Chemical (elemental) composition of the earth's crust, soils, rocks and minerals.	2
2.	Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.	2
3.	Soil colloids :inorganic and organic colloids-origin of charge	1
4.	Concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils	2
5.	Diffuse double layer theories of soil colloids	2
6.	Zeta potential, stability, coagulation/flocculation and peptization of soil colloids;	2
7.	Electrometric properties of soil colloids	1
8.	Sorption properties of soil colloids;	1
9.	Soil organic matter fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.	2
10.	Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept	3
11.	Clay-membrane electrodes and ionic activity measurement	1
12.	Thermodynamics, statistical mechanics; anion and ligand exchange- inner-sphere and outer-sphere surface complex formation	1
13.	Fixation of oxy-anions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange	1

14.	AEC, CEC	1
15.	Experimental methods to study ion exchange phenomena and practical implications in plant nutrition	1
16.	Potassium, phosphate and ammonium fixation in soils covering specific and non- specific sorption; precipitation-dissolution equilibria; Concept of quantity/intensity (Q/I) relationship; step and constant-rate K; management aspects.	3
17.	Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity	2
18.	Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.	2
19.	Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry	2
Total		**32**

Practical

Preparation of saturation extract, measurement of pH, EC, CO_2^-, HCO_3^-, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometricandconductometrictitrationofsoilhumicandfulvicacids,(E4/E6)ratioofsoilhumicandfulvicacidsbyvisiblespectrophotometricstudiesandtheD(E4/E6)valuesattwopHvalues,Adsorption-desorptionofphosphate/sulphatebysoilusingsimpleadsorptionisotherm,Constructionofadsorption envelopeofsoilsbyusingphosphate/fluoride/sulphateandascertainingthemechanismoftheligandexchangeprocessinvolved,Determinationoftitratableacidityofanacidsoilby$BaCl_2$-TEAmethod, DeterminationofQ/Irelationshipofpotassium,Determinationoflimerequirementofanacidsoilbybuffermethod,Determinationofgypsumrequirementofanalkalisoil.

Lecture Schedule-Practical

S. No	Topics	No. of Lectures
1.	Preparation of saturation extract	1
2.	Measurement of pH, EC, CO_3^-, HCO_3^-	1
3.	Measurement of Ca, Mg, K and Na	1
4.	Determination of CEC and AEC of soils	1
5.	Analysis of equilibrium soil solution for pH	1
6.	Analysis of equilibrium soil solution for Eh	1
7.	Analysis of equilibrium soil solution for EC	1
8.	Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method	1

9.	Extraction of humic substances	1
10.	Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E4/E6) values at two pH values	1
11.	Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm	1
12.	Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved	1
13.	Determination of titratable acidity of an acid soil by $BaCl_2$-TEA method	1
14.	Determination of Q/I relationship of potassium	1
15.	Determination of lime requirement of an acid soil by buffer method	1
16.	Determination of gypsum requirement of an alkali soil	1
Total		**16**

SuggestedReadings

1. *Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.*
2. *Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.*
3. *Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & sons.*
4. *Greenland DJ and Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.*
5. *McBride MB. 1994. Environmental Chemistry of Soils. Oxford University Press.*
6. *Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford University Press.*
7. *Sposito G. 1984. The Surface Chemistry of Soils. Oxford University Press.*
8. *Sposito G. 1989. The Chemistry of Soils. Oxford University Press.*
9. *Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley & Sons.*
10. *Van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.*

SOILS 512 SOILMINERALOGY,GENESISANDCLASSIFICATION 3(2+1)

Objectives

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

UnitI

Fundamentals of crystallography, space lattice, coordination theory, isomorphismandpolymorphism.

UnitII

Classification,structure,chemicalcompositionandpropertiesofclayminerals;genesisandtransformationofcrystallineandnon-crystallineclayminerals;identification techniques; amorphous soil constituents and other non-crystallinesilicate minerals and their identification; clay minerals in Indian soils, role of clayminerals in plant nutrition, interaction of clay with humus, pesticides and heavymetals.

UnitIII

Factorsofsoilformation,soilformationmodels;soilformingprocesses;weatheringof rocks and mineral transformations; soil profile; weathering sequences of mineralswithspecialreferencetoIndiansoils.

UnitIV

Concept of soil individual; soil classification systems- historical developments andmodern systems of soil classification with special emphasis on soil taxonomy; soilclassification,soilmineralogyandsoilmaps- usefulness.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1	Fundamentals of crystallography, isomorphism and polymorphism	1
2	Structural chemistry and classification of minerals	1
3	Chemical composition and properties of clay minerals	2
4	Genesis and transformation of crystalline and non-crystalline clay minerals	2
5	Amorphous soil constituents and other non-crystalline silicate minerals; clay minerals in Indian soils.	2
6	Soil morphology and micromorphology	2
7	Role of clayminerals in plant nutrition, interaction of clay with humus, pesticides and heavymetals.	2
8	Soil formation, factors of soil formation, soil forming processes	2
9	Weathering of rocks and mineral transformations	3
10	Soil profile; weathering sequences of minerals with special reference to Indian soils	2
11	Concept of soil individual and soil classification systems	2
12	Historical developments and modern systems of soil classification with special emphasis on soil taxonomy	3
13	Soil classification, soil mineralogy	3
14	Soil survey and its types; soil survey techniques - conventional and modern	2
15	Soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps	2
16	Soil maps – usefulness	1
Total		**32**

Practical

- Separationofsand,siltandclayfractionfromsoil
- DeterminationofspecificsurfaceareaandCECofclay
- Identificationandquantificationofmineralsinsoilfractions
- Morphologicalpropertiesofsoilprofileindifferentlandforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its applicationinsoilformation
- Groupingsoilsensingavailabledatabaseintermsofsoilquality

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1	Separationofsand,siltandclayfractionfromsoil	2
2	DeterminationofspecificsurfaceareaandCECofclay	2
3	Identificationandquantificationofmineralsinsoilfractions	2
4	Morphologicalpropertiesofsoilprofileindifferentlandforms	2
5	Classification of soils using soil taxonomy	3
6	Calculation of weathering indices and its applicationinsoilformation	3
7	Groupingsoilsensingavailabledatabaseintermsofsoilquality	2
Total		**16**

SuggestedReadings

1. *BradyNCandWeilRR.2002.TheNatureandPropertiesofSoils.13thEd.PearsonEdu. BuolEW,HoleED,Mac CrackenRJandSouthardRJ.1997.SoilGenesis andClassification.4thEd.PanimaPubl.*
2. *DixonJBandWeedSB.1989.MineralsinSoilEnvironments.2ndEd.SoilScienceSocietyofAmerica,Madison.*
3. *GrimRE.1968.ClayMineralogy.McGrawHill.*
4. *Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.*
5. *Sehgal J. 2002. Introductory Pedology: Concepts and Applications. New Delhi*
6. *Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani.*
7. *USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.*
8. *WadeFAandMattoxRB.1960.ElementsofCrystallographyandMineralogy.Oxford&IBH.*
9. *Wilding LP and Smeck NE. 1983. Pedogenesis and Soil Taxonomy: II. The Soil Orders. Elsevier.*
10. *Wilding NE and Holl GF. (Eds.). 1983. Pedogenesis and Soil Taxonomy. I.*

SOIL513 ANALYTICALTECHNIQUEANDINSTRUMENTAL METHODSIN SOILANDPLANTANALYSIS **2(0+2)**

Objectives

Tofamiliarizethestudentswithcommonlyusedinstruments–theirworking,preparationsofcommonanalyticalreagentsforqualitativeandquantitativeanalysisofbothsoilaswellasplantsamples.

Practical

UnitI

Preparationofsolutionsforstandardcurves,indicatorsandstandardsolutionsforacid-base,oxidationreductionandcomplexometrictitration;soil,waterandplantsamplingtechniques,their processingandhandling.

UnitII

Determinationofnutrientpotentialsandpotentialbufferingcapacitiesofsoilsforphosphorusandpotassium;estimationofphosphorus,ammoniumandpotassiumfixationcapacitiesofsoils.

UnitIII

Principles of visible, ultra violet and infrared spectrophotometery, atomic absorption,flame-photometry,inductivelycoupledplasmaspectrometry;chromatographictechniques,massspectrometryandX-raydefractrometery;identificationofmineralsbyX-raybydifferentmethods,CHNSanalyzer.

UnitIV

Electrochemicaltitrationofclays;estimationofexchangeablecations(Na,Ca,Mg,K);estimationofrootcationexchangecapacity.

UnitV

Wet digestion/fusion/extraction of soil with aqua regia with soil for elemental analysis;triacid/di-aciddigestionofplantsamples;determinationofavailableandtotalnutrients(N,P,K,S,Ca,Mg,Zn,Cu,Fe,Mn,B,Mo)insoils;determinationoftotalnutrients(N,P,K,S,Ca,Mg,Zn,Cu,Fe,Mn,B,Mo)inplants

UnitVI

Drawingnormalizedexchangeisotherms;measurementofredoxpotential.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Preparation of solutions for standard curves, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration	1
2.	Soil, water and plant sampling techniques, their processing and handling.	1
3.	Determination of nutrient potential and potential buffering capacity of phosphorus	1
4.	Determination of nutrient potential and potential buffering capacity of potassium	1
5.	Estimation of phosphorus fixation capacity of soil	1

6.	Estimation of ammonium fixation capacity of soil	1
7.	Estimation of potassium fixation capacity of soil	1
8.	Principles of visible, ultra violet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractometry; identification of minerals by X-ray by different methods, CHNS analyzer.	2
9.	Electrochemical titration of clays	1
10.	Estimation of exchangeable cations (Na, Ca, Mg, K);	1
11.	Estimation of root cation exchange capacity.	1
12.	Wet digestion/fusion/extraction of soil with aqua regia with soil for elemental analysis	1
13.	Triacid/di-acid digestion of plant samples	1
14.	Determination of available and total nitrogen in soil	1
15.	Determination of available and total phosphorus in soil	1
16.	Determination of available and total potassium in soil	1
17.	Determination of available and total Sulphur in soil	1
18.	Determination of available and total calcium, magnesium in soil	1
19.	Determination of available and total iron, copper, manganese, zinc in soil	1
20.	Determination of available and total boron in soil	1
21.	Determination of available and total molybdenum in soil	2
22.	Determination of nitrogen in plant	1
23.	Determination of phosphorus in plant	1
24.	Determination of potassium in plant	1
25.	Determination of sulphur in plant	1
26.	Determination of calcium and magnesium in plant	1
27.	Determination of iron, copper, manganese, zinc in plant	1
28.	Determination of boron in plant	1
29.	Determination of molybdenum in plant	1
30.	Drawing normalized exchange isotherms; measurement of redox potential	1
Total		**32**

Suggested Readings

1. *Hesse P. 971. Textbook of Soil Chemical Analysis. William Clowes & Sons.*
2. *Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.*
3. *Keith A Smith 1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.*
4. *Kenneth Helrich 1990. Official Methods of Analysis. Association of Official Analytical Chemists.*
5. *Page AL, Miller RH and Keeney DR. 1982. Methods of Soil Analysis. Part II. SSSA, Madison.*
6. *Piper CE. Soil and Plant Analysis. Hans Publ.*
7. *Singh D, Chhonkar PK and Pandey RN. 1999. Soil Plant Water Analysis-*

AMethodsManual.IARI,NewDelhi.
8. *TanKH.2003.SoilSampling,PreparationandAnalysis.CRCPress/Taylor&Francis.*
9. *TandonHLS.1993.MethodsofAnalysisofSoils,FertilizersandWaters.FDCO,NewDelhi.*
10. *VogelAL.1979.ATextbookofQuantitativeInorganicAnalysis.ELBSLongman.*

SOIL 521 SOILFERTILITYANDFERTILIZERUSE 3(2+1)

Objectives

To impart knowledge about soil fertility and to understand the role of manures and fertilizers in supplying nutrients to plants so as to improvenutrient/fertilizer use efficiency.

Theory

UnitI

Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources-fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

UnitII

Soil and fertilizer nitrogen-sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers- behavior in soils and management under field conditions. Potassium- forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit IV

Sulphur-source, forms, fertilizers and their behavior in soils; role in crops and human health; calcium and magnesium-factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit V

Micronutrients- critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VI

Common soil test methods for fertilizer recommendations; quantity- intensity relationships; soil test crop response correlations and response functions.

Unit VII

Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers use in soils and crops of India.

Unit VIII

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, determination of critical limit, DRIS.

Unit IX

Definition and concepts of soil health and soil quality; long term effects of fertilizers and soil quality.

Lecture Schedule -Theory

S. No	Topics	No. of Lectures
1	Soil fertility and soil productivity; fertility status of major soils group of India	1
2	Nutrient sources – fertilizers and manures	1
3	Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms	1
4	Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification	1
5	Biological nitrogen fixation -types, mechanism, microorganisms and factors affecting	1
6	Nitrogenous fertilizers and their fate in soils	1
7	Management of nitrogenous fertilizer in lowland and upland conditions for high fertilizer use efficiency.	1
8	Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils	1
9	Factors affecting phosphorus availability in soils	1
10	Phosphatic fertilizers - behavior in soils and management under field conditions.	1
11	Potassium - forms, equilibrium in soils and its agricultural significance	1
12	Mechanism of potassium fixation in soil	1
13	Management of potassium fertilizers under field conditions	1
14	Sulphur - source, forms, fertilizers and their behavior in soils	1
15	Calcium and magnesium– factors affecting their availability in soils	1
16	Management of Sulphur, calcium and magnesium fertilizers under field conditions	1
17	Factors affecting micronutrient availability and correction of their deficiencies in plants	2
18	Role of chelates in nutrient availability	1
19	Common soil test methods for fertilizer recommendations	1
20	Quantity– intensity relationships	1
21	Soil test crop response correlations and response functions	1
22	Fertilizer use efficiency and factors affecting the FUE	1

23	Blanket fertilizer recommendations – usefulness and limitations	1
24	Site-specific nutrient management	1
25	Plant need based nutrient management	1
26	Integrated nutrient management and its importance and components	1
27	Speciality fertilizers concept, need and category. Current status of speciality fertilizers use in soils and crops of India.	1
28	Soil fertility evaluation: Biological methods, use of visual symptoms of nutrient deficiency or toxicity	1
29	Soil fertility evaluation: Plant analysis method – DRIS methods, critical levels in plants, rapid tissue tests, indicator plants	1
30	Soil fertility evaluation: Soil analysis methods – critical levels of different nutrients in soil.	1
31	Interpretation and calibration of soil test values and fertilizer recommendations to crops	1
32	Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.	1
Total		**32**

Practical

- Soilandplantsamplingandprocessingforchemicalanalysis
- Determination ofsoilpH,totalandorganiccarboninsoil
- Chemicalanalysisofsoilfortotalandavailablenutrients(majorandmicro)
- Analysisofplantsforessentialelements(majorandmicro)

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Determination of total nitrogen in soil	1
2.	Determination of total phosphorus in soil	1
3.	Determination of total potassium in soil	1
4.	Determination of available nitrogen in soil	1
5.	Determination of available phosphorus in soil	1
6.	Determination of available potassium in soil	1
7.	Determination of available sulphur in soil	1
8.	Determination of available boron in soil	1
9.	Determination of available molybdenum in soil	1
10.	Determination of iron, copper, manganese and zinc in soil	1
11.	Determination of nitrogen in plant	1
12.	Determination of phosphorus in plant	1
13.	Determination of potassium in plant	1
14.	Determination of sulphur in plant	1
15.	Determination of boron and molybdenum in plant	1
16.	Determination of iron, copper, manganese and zinc in plant	1
Total		**16**

SuggestedReadings

1. *BradyNCandWeilRR.2002.TheNatureandPropertiesofSoils.13thEd.PearsonEdu.*
2. *Kabata-PendiasAandPendiasH.1992.TraceElementsinSoilsandPlants.CRCPress.*
3. *KannaiyanS,KumarKandGovindarajanK.2004.BiofertilizersTechnology.ScientificPubl.*
4. *LeighJG.2002.NitrogenFixationattheMillennium.Elsevier.*
5. *Mengel K and Kirkby EA. 1982.PrinciplesofPlantNutrition. International Potash Institute,Switzerland.*
6. *MortvedtJJ,ShumanLM,CoxFRandWelchRM.1991.MicronutrientsinAgriculture.2ndEd.SSSA,Madison.*
7. *PierzinskyGM,SimsTJandVanceJF.2002.SoilsandEnvironmentalQuality.2ndEd.CRCPress.*
8. *StevensonFJandColeMA.1999.CyclesofSoil:Carbon,Nitrogen,Phosphorus,Sulphur,Micronutrients.JohnWiley&Sons.*
9. *TisdaleSL,NelsonSL,BeatonJDandHavlinJL.1999.SoilFertilityandFertilizers.5thEd.PrenticeHallofIndia.*
10. *Troeh FR and Thompson LM. 2005.Soils and Soil Fertility.Blackwell*

SOIL 522 SOILBIOLOGYANDBIOCHEMISTRY 3(2+1)

Objectives

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UnitI

Soil biota,soilmicrobial ecology,typesoforganismsin differentsoils;soilmicrobialbiomass;microbialinteractions;un-culturablesoil biota.

UnitII

Microbiologyandbiochemistryofroot-soilinterface;phyllosphere;soilenzymes,origin,activitiesandimportance;soilcharacteristicsinfluencinggrowthandactivityofmicroflora;RootrhizosphereandPGPR.

UnitIII

Microbialtransformationsofnitrogen,phosphorus,sulphur,ironandmanganeseinsoil;biochemicalcompositionandbiodegradationofsoilorganicmatterandcropresidues,microbiologyandbiochemistryofdecompositionofcarbonaceousandprotenaceousmaterials,cyclesofimportantorganicnutrients.

UnitIV

Organicwastesandtheiruseforproductionofbiogasandmanures;bioticfactorsinsoildevelopment;microbialtoxinsinthesoil.

UnitV

Preparationandpreservationoffarmyardmanure,animalmanures,ruralandurbancompostsandvermicompost.

UnitVI

Biofertilizers–
definition,classification,specifications,methodofproductionandroleincropproduction;FCOspecifications andqualitycontrolofbiofertilizers.

UnitVII

Biological indicators of soil quality; bioremediation of contaminated soils; microbialtransformationsofheavymetalsinsoil;roleofsoilorganismsin pedogenesis– importantmechanismsandcontrollingfactors;soilgenomicsandbio prospecting;soilsicknessduetobiologicalagents;xenobiotics;antibioticproductioninsoil.

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1.	Soil microbiology, Soil biota, soil microbial ecology	1
2.	Classification of micro-organism and types of organisms in different soils	2
3.	Soil microbial biomass	1
4.	Microbial interactions	1
5.	Soil biota in culturale and un-culturale land and factors affecting it	1
6.	Microbiology and biochemistry of root-soil interface	2
7.	Phyllosphere and rhizosphere chemistry	2
8.	Soil enzymes, origin, activities and importance	1
9.	Soil characteristics influencing growth and activity of microflora. Root rhizosphere and PGPR.	2
10.	Microbial transformations of nitrogen in soil	1
11.	Microbial transformations of phosphorus in soil	1
12.	Microbial transformations of sulphur in soil	1
13.	Microbial transformations of iron in soil	1
14.	Microbial transformations of manganese in soil	1
15.	Biochemical composition and biodegradation of soil organic matter and crop residues	2
16.	Humus formation; cycles of important organic nutrients.	1
17.	Biodegradation of organic wastes and their use for production of biogas and manures	2
18.	Biotic factors in soil development	1
19.	Microbial toxins in the soil	1
20.	Preparation and preservation of farmyard manure and animal manure	1
21.	Composting methods and Rural and urban compost	1
22.	Vermicomposting	1
23.	Biofertilizers – definition, classification, specifications, method of production and role in crop production	2
24.	FCO specifications and quality control of biofertilizers	1
25.	Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil;	1
26.	Role of soil organisms in pedogenesis – important mechanisms and controlling factors	1

27.	Soil genomics and bio prospecting; soil sickness due to biological agents; Xenobiotics; antibiotic production in soil.	1
Total		**32**

Practical

- Determinationofsoilmicrobialpopulation
- Soilmicrobialbiomasscarbon
- Elementalcomposition,fractionationoforganicmatterandfunctionalgroups
- Decompositionoforganicmatterinsoil
- Soilenzymes
- Measurementofimportantsoilmicrobialprocessessuchasammonification,nitrification , N_2fixation, S oxidation, P solubilization and mineralization of othermicronutrients

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Determination of soil microbial population (Fungi, Bacteria and Actinomycetes)	2
2.	Determination of soil microbial biomass carbon	2
3.	Determination of Soil microbial biomass nitrogen	2
4.	Determination of Soil microbial biomass phosphorus	2
5.	Fractionation of organic matter (HA, FA, humin, lignin and humus) and functional groups	3
6.	Soil enzymes	2
7.	Measurement of important soil microbial processes such as nitrification, N_2 fixation, S oxidation, P solubilization	3
Total		**16**

SuggestedReadings

1. *PaulEAandClarkFE.SoilMicrobiologyandBiochemistry.*
2. *LynchJM.SoilBiotechnology*
3. *WilleyJM,LindaM.SherwoodandWoolvertonCJ.Prescott'sMicrobiology.*
4. *Subba Rao NS.AdvancesInAgriculturalMicrobiology.*

SOIL 523 MANAGEMENTOFPROBLEMATICSOILSANDWATER 3 (2+1)

Objectives

To educate students about basic concepts of problematic soils and brackish water, andtheir management. Attention will be on management of problem soils and safe useofbrackishwaterinrelationtocropproduction.

Theory

UnitI

Area and distribution of problematic soils–acidic, saline, sodic and physically degradedsoils;originandbasicconceptofproblematicsoils,andfactorsresponsible.

UnitII

Morphological features of saline, sodic and saline-sodic soils; characterization ofsalt-affected soils-soluble salts, ESP, pH; physical, chemical and microbiologicalproperties.

UnitIII

Management of salt-affected soils; salt tolerance of crops- mechanism and ratings;salt stress meaning and its effect on crop growth, monitoring of soils alkalinity in thefield;managementprinciplesforsandy,clayey,redlateriticanddrylandsoils.

UnitIV

Acid soils-nature of soil acidity, sources of soil acidity; effect on plant growth, limerequirementofacidsoils;managementofacidsoils;biologicalsicknessofsoilsanditsmanagement.

UnitV

Qualityofirrigationwater;managementofbrackishwaterforirrigation;saltbalanceunder irrigation; characterization of brackish waters, area and extent; relationshipinwateruseandquality.Agronomic practices in relation to problematic soils; cropping pattern for utilizingpoorqualityground waters.

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1.	Area and distribution of problematic soils–acidic, saline, sodic and physically degraded soils;	2
2.	Origin and basic concept of problematic soils, and factors responsible.	3
3.	Morphological features of saline, sodic and saline-sodic soils	2
4.	Characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties	2
5.	Management of salt-affected soils	2
6.	Salt tolerance of crops - mechanism and ratings	2
7.	Monitoring of soil salinity in the field	1
8.	Management principles for sandy, clayey, red lateritic and dry land soils	3
9.	Acid soils - nature of soil acidity, sources of soil acidity	1
10.	Soil acidity effect on plant growth and lime requirement of acid soils	2
11.	Management of acid and acid sulphate soils	2
12.	Biological sickness of soils and its management	2
13.	Quality of irrigation water and their crop response	2
14.	Management of brackish water for irrigation	2
15.	Salt balance under irrigation	1
16.	Characterization of brackish waters, area and extent, relationship in water use and quality	2
17.	Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.	1
Total		**32**

Practical

Characterizationofacid,acidsulfate,salt-affectedandcalcareoussoils,Determinationofcations(Na^+,K^+,Ca^{++}andMg^{++})ingroundwaterandsoilsamples,Determinationofanions(Cl^-,SO_4^{--},CO_3^{--}andHCO_3^-)ingroundwatersandsoilsamples,Limeandgypsumrequirementsofacidandsodicsoils.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Characterization of acid and acid sulfate soils	1
2.	Characterization of salt-affected soils	1
3.	Characterization of calcareous soils	1
4.	Determination of Ca^{++} and Mg^{++} in soil and ground water	1
5.	Determination of Potassium in ground water	1
6.	Determination of Potassium in soil	1
7.	Determination of sodium in ground water	1
8.	Determination of sodium in soil	1
9.	Determination of CO_3^{--} and HCO_3^- in ground waters	1
10.	Determination of CO_3^{--} and HCO_3^- in soil	1
11.	Determination of chloride in ground waters	1
12.	Determination of chloride soil	1
13.	Determination of sulphate (SO_4^{--}) in ground waters	1
14.	Determination of sulphate (SO_4^{--}) in soil	1
15.	Determination of gypsum requirement of sodic soil	1
16.	Determination of lime requirement of acid soil	1
Total		**16**

SuggestedReadins

1. *BearFE.1964.ChemistryoftheSoil.Oxford&IBH.*
2. *JurinakJJ.1978.Salt-affectedSoils.DepartmentofSoilScience&Biometeorology.UtahStateUniversity*
3. *USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford&IBH*

SOIL 531 SOIL PHYSICS 3(2+1)

Objectives

Toimpartbasicknowledgeaboutsoilphysicalpropertiesandprocessesinrelationtoplantgrowth.

Theory

UnitI

Basicprinciplesofphysicsappliedtosoils,soilasathreephasesystem.

UnitII

Soiltexture,texturalclasses,mechanicalanalysis,specificsurface.

UnitIII

Soilconsistency;dispersionandworkabilityofsoils;soilcompactionandconsolidation;soilstrength;swellingandshrinkage-basicconcepts.

Alleviationofsoilphysicalconstraintsforcropproduction.Soilerosionanderodibility

UnitIV

Soilstructure-genesis,types,characterizationand management soil structure;soilaggregation,aggregatestability;soiltilth,characteristicsofgoodsoiltilth;soilcrusting -mechanism, factors affecting and evaluation; soil conditioners; puddling,itseffectonsoilphysicalproperties;clodformation.

UnitV

Soilwater:contentandpotential,soilwaterretention,soil-waterconstants,measurement of soil water content, energy state of soil water, soil water potential,soil-moisturecharacteristiccurve;hysteresis,measurementofsoil-moisturepotential.

UnitVI

Waterflowinsaturatedandunsaturatedsoils,Poiseuille'slaw,Darcy'slaw;hydraulicconductivity,permeabilityandfluidity,hydraulicdiffusivity;measurementof hydraulicconductivityinsaturatedandunsaturatedsoils.

UnitVII

Infiltration;internaldrainageandredistribution;evaporation;hydrologiccycle,fieldwaterbalance;soil-plant-atmospherecontinuum.

UnitVIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurementofsoilaeration;aerationrequirementforplantgrowth;soilairmanagement.

Modesofenergytransferinsoils;energybalance;thermalpropertiesofsoil;measurement of soil temperature; soil temperature in relation to plant growth;soil temperaturemanagement.

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1.	Scope of soil physics and its relation with other branches of soil science, Soil as a three phase system	2
2.	Soil texture, textural classes, mechanical analysis, specific surface	2
3.	Soil consistence; dispersion and workability of soils	2
4.	Soil compaction and consolidation	1
5.	Soil strength; swelling and shrinkage - basic concepts	1
6.	Alleviation of soil physical constraints for crop production. Soil erosion and erodibility	
7.	Soil structure - genesis, types, characterization and management of soil structure	2
8.	Soil aggregation, aggregate stability	1
9.	Soil tilth, characteristics of good soil tilth	1
10.	Soil crusting - mechanism, factors affecting and evaluation	1
11.	Soil conditioners and puddling, its effect on soil physical properties and clod formation.	2
12.	Soil water: content and potential, soil water retention,	1

	soil-water constants, measurement of soil water content, energy state of soil water, soil water potential	
13.	Soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential	1
14.	Water flow in saturated soils	1
15.	Water flow in unsaturated soils	1
16.	Poiseuille's law and Darcy's law	1
17.	Hydraulic conductivity and hydraulic diffusivity	1
18.	Measurement of hydraulic conductivity in saturated and unsaturated soils.	1
19.	Permeability and fluidity	1
20.	Infiltration and Internal drainage and redistribution	1
21.	Evaporation, hydrologic cycle, field water balance	2
22.	Soil-plant-atmosphere continuum	1
23.	Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management	1
24.	Modes of energy transfer in soils	1
25.	Energy balance; thermal properties of soil	1
26.	Measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management	2
Total		**32**

Practical

DeterminationofB.D,P.Dandmassvolumerelationshipofsoil,Mechanicalanalysisbyhydrometerandinternationalpipettemethod,MeasurementofAtterberglimits,Aggregateanalysis-dryandwet,Measurementof soil-water content by different methods, Measurement of soil-water potential byusing tensiometer and gypsum blocks, Determination of soil-moisture characteristicscurveandcomputationofpore-size,distribution,Determinationofhydraulicconductivityundersaturatedandunsaturatedconditions,Determinationofinfiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate,Soil temperature measurements by different methods, Estimation of water balancecomponentsinbareandcroppedfields.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Mechanical analysis by pipette and international methods	1
2.	Determination of bulk density of soil by core sampler method	1
3.	Measurement of atterberg limits	1
4.	Aggregate analysis - dry and wet methods	1
5.	Measurement of soil-water content by different methods	1
6.	Measurement of soil-water potential by using tensiometer	1

7.	Measurement of soil-water potential by using gypsum blocks	1
8.	Determination of soil-moisture characteristics curve and computation of pore-size distribution	1
9.	Determination of hydraulic conductivity under saturated conditions	1
10.	Determination of hydraulic conductivity under unsaturated conditions	1
11.	Determination of infiltration rate of soil	1
12.	Determination of aeration porosity	1
13.	Determination of oxygen diffusion rate	1
14.	Soil temperature measurements	1
15.	Estimation of water balance components in bare fields	1
16.	Estimation of water balance components in bare and cropped fields	1
Total		**16**

SuggestedReadings

1. *Baver LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley & Sons.*
2. *Ghildyal BP and Tripathi RP. 2001. Soil Physics. New Age International.*
3. *Hanks JR and Ashcroft GL. 1980. Applied Soil Physics. Springer Verlag.*
4. *Hillel D. 1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.*
5. *Hillel D. 1980. Applications of Soil Physics. Academic Press.*
6. *Hillel D. 1980. Fundamentals of Soil Physics. Academic Press.*
7. *Hillel D. 1998. Environmental Soil Physics. Academic Press.*
8. *Hillel D. 2003. Introduction to Environmental Soil Physics. Academic Press.*
9. *Indian Society of Soil Science. 2002. Fundamentals of Soil Science. ISSS, New Delhi.*
10. *Kirkham D and Powers WL. 1972. Advanced Soil Physics. Wiley-Interscience.*
11. *Kohnke H. 1968. Soil Physics. McGraw Hill.*
12. *Lal R and Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.*
13. *Oswal MC. 1994. Soil Physics. Oxford & IBH.*

Ph.D. Programme

SOIL 611 PHYSICALCHEMISTRYOFSOIL 2 (2+0)

Objectives

To impart knowledge about modern concepts of physical chemistry of soils andclays,withemphasisonunderstandingtheprocessesinvolvedwithpracticalsignificance.

Theory

UnitI

Colloidalchemistryofinorganicandorganiccomponentsofsoils-theirformation,clayorganicinteraction.

Unit II

Predictiveapproachesforcationexchangeequilibria-thermodynamics,empiricaland diffuse double layer theory (DDL)- relationships among different selectivitycoefficients;structureandpropertiesofdiffusedoublelayer.

UnitIII

Thermodynamicsofnutrienttransformationsinsoils;Climatechangeeffectsonminerologyandsurfacepropertiesofvariablecharge;cationicandanionicexchangeandtheirmodels,molecularinteraction.

UnitIV

Adsorption/desorptionisotherms-Langmuiradsorptionisotherm,Freundlichadsorptionisotherm,normalizedexchangeisotherm,BET equation;selectiveandnon-selective adsorption of ions on in organic surfaces and organic surfaces of soilmaterials(citationofutilityinagriculturalsystem).

UnitV

Common solubility equilibria-carbonates, iron Oxide and hydroxides, aluminumsilicate,aluminumphosphate;electrochemicalpropertiesofclays(citationofexamplesfromagriculturaluse).

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1.	Colloidal chemistry of inorganic components of soils – their formation clay organic interaction.	2
2.	Colloidal chemistry of organic components of soils – their formation, clay organic interaction.	2
3.	Predictive approaches for cation exchange equilibria - thermodynamics	2
4.	Empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients	2
5.	Structure and properties of diffuse double layer.	2
6.	Thermodynamics of nutrient transformations in soils	2
7.	Cationic and anionic exchange and their models, molecular interaction	2
8.	Adsorption/desorption isotherms	2
9.	Langmuir adsorption isotherm	2
10.	Freundlich adsorption isotherm	2
11.	Normalized exchange isotherm	2
12.	BET equation	2
13.	Selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system)	3
14.	Common solubility equilibria of carbonates	1
15.	Common solubility equilibria of iron oxide and hydroxides	1
16.	Common solubility equilibria of aluminum silicate	1
17.	Common solubility equilibria of aluminum phosphate	1

18.	Electrochemical properties of clays	1
Total		**32**

SuggestedReadings

1. *BearRE.1964.ChemistryoftheSoil.Oxford&IBH.*
2. *BoltGHandBruggenwertMGM.1978.SoilChemistry.Elsevier.*
3. *FriedMandBroeshartH.1967.SoilPlantSysteminRelationtoInorganicNutrition.Academic Press.*
4. *Greenland DJandHayesMHB.1981.Chemistry ofSoilProcesses.JohnWiley& Sons.*
5. *GreenlandDJandHayesMHB.1978.ChemistryofSoilConstituents.JohnWiley&Sons.*
6. *JurinakJJ.1978.ChemistryofAquaticSystems.DepartmentofSoilScienceandBiometeorology,UtahStateUniversity*
7. *McBrideMB.1994.EnvironmentalChemistryofSoils.OxfordUniversityPress.*
8. *SparksDL.1999.SoilPhysicalChemistry.2ndEd.CRCPress.*
9. *SpositoG.1981.TheThermodynamicsofSoilSolutions.OxfordUniversityPress.*
10. *SpositoG.1984.TheSurfaceChemistryofSoils.OxfordUniversityPress.*
11. *SpositoG.1989.TheChemistryofSoils.OxfordUniversityPress.*
12. *StevensonFJ.1994. Humus Chemistry. 2nd Ed.John Wiley.*
13. *vanOlphanH.1977.IntroductiontoClayColloidChemistry.JohnWiley&Sons.*

SOIL 612 SOILGENESISANDMICROMORPHOLOGY 2 (2+0)

Objectives

Toimpartknowledgeaboutthepedogenicprocessesinsoilsandtoacquaintwiththemicro-pedologicalstudyofsoilprofile.

Theory

UnitI

Pedogenicevolutionofsoils;soilcompositionandcharacterization.

UnitII

Weatheringandsoilformation–factorsandpedogenicprocesses;stabilityandweatheringsequencesofminerals.

UnitIII

Assessmentofsoilprofiledevelopmentbymineralogicalandchemicalanalysis.

UnitIV

Micro-pedologicalfeaturesofsoils–theirstructure,fabricanalysis,roleingenesisandclassification.

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1.	Pedogenic evolution of soils	1
2.	Soil compositionandcharacterization	1
3.	Weathering and soil formation	2
4.	Soilformation–factors	1
5.	Pedogenic Processes in soil formation	2
6.	Fundamental Pedogenic Processes	3
7.	Specific Pedogenic Processes	3
8.	Physical Weathering	1

9.	Chemical Weathering	1
10.	Biological Weathering	1
11.	Weathering of minerals	3
12.	Weathering sequence of minerals	2
13.	Stages of weathering of soil minerals	2
14.	Role of weathering in soil formation	2
15.	Assessment of soil profile development by mineralogical and chemical analysis.	3
16.	Micro-pedologicalfeaturesofsoils–theirstructure, fabricanalysis,	3
17.	Roleingenesisandclassification.	1
Total		**32**

SuggestedReadings

1. *BradyNCandWeilRR.2002.TheNatureandPropertiesofSoils.13thEd.PearsonEdu.*
2. *BuolEW,HoleED,MacCrackenRJ&SouthardRJ.1997.SoilGenesisandClassification.4thEd.PanimaPubl.*
3. *DixonJBandWeedSB.1989.MineralsinSoilEnvironments.2ndEd.SoilScienceSocietyofAmerica,Madison.*
4. *GrimRE.1968.ClayMineralogy.McGrawHill.*
5. *IndianSocietyofSoilScience2002.FundamentalsofSoilScience.ISSS,NewDelhi.*
6. *SehgalJ.2002.IntroductoryPedology:ConceptsandApplications.NewDelhi*
7. *SehgalJ.2002.Pedology-ConceptsandApplications.Kalyani.*
8. *USDA.1999. SoilTaxonomy. HandBook No.436.2ndEd. USDANRCS,Washington.*
9. *WadeFAandMattoxRB.1960.ElementsofCrystallographyandMineralogy.Oxford&IBH.*

SOIL 613 RECENTTRENDSINSOILPHYSICS 2 (2+0)

Objectives

Toprovideknowledgeofmodernconcepts insoilphysics.

Theory

UnitI

Soil-waterinteractions,soilwaterpotential,freeenergyandthermodynamicbasisofpotentialconcept,chemicalpotentialofsoilwaterandentropyofthesystem,soil-plant-atmosphericcontinuum(SPAC).

UnitII

Fundamentalsoffluidflow,Poiseuilleslaw,Laplace'sequation,Darcy'slawinsaturated and unsaturated flows; development of differential equations in saturatedandunsaturatedwater flow,capillaryconductivitydiffusivity;limitationsandofDarcy'slaw;numericalsolutionforone dimensionalwater flow.

UnitIII

Theoriesofhorizontalandverticalinfiltrationunderdifferentboundaryconditions.

UnitIV

Movementofsaltsinsoils,modelsformiscible-immiscibledisplacement,diffusion,massflowanddispersionofsolutesandtheirsolutionsthroughdifferentialequations;break-throughcurves.

UnitV

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil,heat transfer in soils, differential equation of heatflow, measurement of thermalconductivityofsoil;Soil,Plant,Waterrelations-Plantuptakeofsoilmoisture,Waterbalanceandenergybalanceinthefield;irrigationandwateruse efficiency.

UnitVI

Soilcrustandclodformation;structuralmanagementofpuddledricesoils;soilconditioning-concept,soilsconditioners-types,characteristics,workingprinciples,significanceinagriculture.

UnitVII

Solar and terrestrial radiation measurement, dissipation and distribution in soil-cropsystems;predictionofevapotranspirationusingaerodynamicandcanopytemperature-basedmodels;canopytemperatureandleafdiffusionresistanceinrelation to plant water deficit; evaluation of soil and plant water status using infra-redthermometer.

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1	Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept,	1
2	Chemical potential of soil water and entropy of the system.	1
3	Soil-Plant-Atmospheric Continuum (SPAC).	1
4	Fundamentals of fluid flow in saturated and unsaturated flows;capillary conductivity and diffusivity	1
5	Poiseuilles law, Laplace's equation in saturated and unsaturated flows;capillary conductivity and diffusivity	2
6	Darcy's law in saturated and unsaturated flows;capillary conductivity and diffusivity	1
7	Limitations of Darcy's law; numerical solution for one dimensional water flow.	1
8	Theories of horizontal infiltration under different boundary conditions.	1
9	Theories of vertical infiltration under different boundary conditions.	1
10	Movement of salts in soils,	1
11	Models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations	2
12	Break-through curves of salt movement in soil	1
13	Soil air and aeration,	1
14	Mass flow and diffusion processes of air movement	1
15	Thermal properties of soil,	2
16	Heat transfer in soils	1
17	Differential equation of heat flow in soil	1

18	Measurement of thermal conductivity of soil.	1
19	Soil crust and clod formation	1
20	Structural management of puddled rice soils;	1
21	Soil conditioners	1
22	Types and characteristics of soil conditioners	1
23	Working principles of soil conditioners	1
24	Significance of soil conditioners in agriculture.	1
25	Solar and terrestrial radiation measurement	1
26	Dissipation and distribution solar and terrestrial radiation in soil-crop systems	1
27	Prediction of evapotranspiration using aerodynamic and canopy temperature-based models;	1
28	Canopy temperature and leaf diffusion resistance in relation to plant water deficit	1
29	Evaluation of soil and plant water status using infra-red thermometer.	1
Total		**32**

SuggestedReadings

1. *BaverLD,GardnerWHandGardnerWR.1972.SoilPhysics.JohnWiley&Sons.*
2. *HanksandAscheroft.1980.AppliedSoilPhysics.SpringerVerlag.*
3. *HillelD.1980.ApplicationsofSoilPhysics.AcademicPress.*
4. *HillelD.1980.EnvironmentalSoilPhysics.AcademicPress.*
5. *IndianSocietyofSoilScience2002.FundamentalsofSoilScience.ISSS,NewDelhi.*
6. *KirkhamDandPowersWL.1972.AdvancedSoilPhysics.WileyInterscience.*
7. *LalRandShuklaMK.2004.PrinciplesofSoilPhysics.MarcelDekker.*
8. *OswalMC.1994.SoilPhysics.Oxford&IBH.*

SOIL 621 MODERNCONCEPTINSOILFERTILITY 2 (2+0)

Objectives

Toprovideknowledgeofmodernconceptsofsoilfertilityandnutrientuseincropproduction.

Theory

UnitI

Nutrientavailability-conceptandrelationships,modernconceptsofnutrientsavailability; soil colloids and nutrient availability; soil amendments and availabilitymaintenanceofnutrients,soilsolutionandplantgrowth;nutrientresponsefunctionsandavailabilityindices.

UnitII

Nutrientmovementinsoils;nutrientabsorptionbyplants;mechanisticapproachto nutrient supply and uptake by plants; models for transformation and movementofmajormicronutrientsinsoils.

UnitIII

Chemicalequilibria(includingsolid-solutionequilbria)involvingnutrient ionsinsoils,particularlyinsubmergedsoils;Kineticstudiesofnutrientsinsoils.

UnitIV

Modernconceptsoffertilizerevaluation,nutrientuseefficiencyandnutrientbudgeting.

UnitV

Modern conceptsinfertilizerapplication;soilfertilityevaluationtechniques;roleofsoiltestsinfertilizeruserecommendations;site-specificnutrientmanagementforprecisionagriculture.

UnitVI

Monitoringphysical,chemicalandbiologicalchangesinsoils;permanentmanurialtrialsandlong-term fertilizer experiments;soil productivity under long-termintensivecropping;direct,residualandcumulativeeffectoffertilizeruse.

UnitVII

Carbon–anutrientcentraltosoilfertility;carboncycleinnature,stocks,poolsandfluxes; greenhouse effect and climate change; carbon sequestration vis-à-vissustenanceofsoilqualityandcropproductivity.

Lecture Schedule-Theory

S. No	Topics	No. of Lectures
1.	Nutrient availability-concept and relationships	1
2.	Modern concepts of nutrient availability	1
3.	Soil colloids and nutrient availability	1
4.	Soil amendments and availability maintenance of nutrients	1
5.	Soil solution and plant growth	1
6.	Nutrient response functions and availability indices	1
7.	Nutrient movement in soils	1
8.	Nutrient absorption by plants	1
9.	Mechanistic approach to nutrient supply and uptake by plants	1
10.	Models for transformation and movement of primary nutrients in soils.	1
11.	Models for transformation and movement of secondary nutrients in soils	1
12.	Models for transformation and movement of micronutrients in soils.	1
13.	Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils	1
14.	Chemical equilibria (including solid-solution equilibria) involving nutrient ions in submerged soils.	1
15.	Modern concepts of fertilizer evaluation	1
16.	Nutrient use efficiency	1
17.	Nutrient budgeting	1
18.	Modern concepts in fertilizer application	1
19.	Soil fertility evaluation: Define, concept and techniques	1
20.	Soil fertility evaluation : Biological methods, use of visual symptoms of nutrient deficiency or toxicity	2

21.	Soil fertility evaluation : Plant analysis method – DRIS methods, critical levels in plants, rapid tissue tests, indicator plants	1
22.	Soil fertility evaluation: Soil analysis methods – critical levels of different nutrients in soil.	1
23.	Role of soil tests in fertilizer use and recommendations	1
24.	Site-specific nutrient management for precision agriculture	1
25.	Monitoring physical, chemical and biological changes in soils	1
26.	Permanent manurial trials and long-term fertilizer experiments	1
27.	Soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use	1
28.	Carbon– a nutrient central to soil fertility	1
29.	Carbon cycle in nature, stocks, pools and fluxes	1
30.	Greenhouse effect and climate change	1
31.	Carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.	1
Total		**32**

SuggestedReadings

1. *BarberSA.1995.SoilNutrientBioavailability.JohnWiley&Sons.*
2. *BarkerVAllenandPilbeamDavidJ.2007.HandbookofPlantNutrition.CRC/Taylor&Francis.*
3. *BradyNCandWeilRR.2002.TheNatureandPropertiesofSoils.13thEd.PearsonEduc.*
4. *CookeGW.1979.TheControlofSoilFertility.CrossbyLockwood&Sons.*
5. *EpsteinE.1987.MineralNutritionofPlants-PrinciplesandPerspectives.InternationalPotashInstitute,Switzerland.*
6. *Kabata-PendiasAlina2001.TraceElementsinSoilsandPlants.CRC/Taylor&Francis.*
7. *KannaiyanS,KumarKandGovindarajanK.2004.BiofertilizersTechnology.Scientific Publ.*
8. *MortvedtJJ,ShumanLM,CoxFRandWelchRM.(Eds.).1991.MicronutrientsinAgriculture. 2ndEd.SoilScienceSocietyofAmerica,Madison.*
9. *PrasadRandPowerJF.1997.SoilFertilityManagementforSustainableAgriculture.CRCPress.*
10. *StevensonFJandColeMA.1999.CyclesofSoil:Carbon,Nitrogen,Phosphorus,Sulphur,Micronutrients.JohnWiley&Sons.*
11. *StevensonFJ.(Ed.).1982.NitrogeninAgriculturalSoils.SoilScienceSocietyofAmerica,Madison.*
12. *TisdaleSL,NelsonWL,BeatonJDandHavlinJL.1990.SoilFertilityandFertilizers.5th Ed.MacmillanPubl.*
13. *WildA.(Ed.).1988.Russell'sSoilConditionsandPlantGrowth.11thEd.Longman.*

SOIL 622 BIOCHEMISTRYOFSOILORGANICMATTER 2(2+0)

Objectives

Toimpartknowledgerelatedtochemistryandreactionsoforganicsubstancesandtheirsignificanceinsoils.

Theory

UnitI

Organicmatterinsoilsanditsmaintenance,roleoforganicmatterinsoilproductivity; humus levels in soils; current thinking on the maintenance of organicmatterinthesoils.Carbonretentionandsequestration.

UnitII

Biochemistry of the humus formation; different pathways for humus synthesis insoil;soilcarbohydratesandlipids.

UnitIII

Nutrient transformation-N, P, S; trace metal interaction with humic substances,significanceofchelationreactionsinsoils.

UnitIV

Reactivefunctionalgroupsofhumicsubstances,adsorptionoforganiccompoundsby clay and role of organic substances in pedogenic soil aggregation processes; clay-organicmattercomplexes.

UnitV

Humus-pesticideinteractionsinsoil,mechanisms.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Organic matter in soils and its maintenance	2
2.	Role of organic matter in soil productivity	2
3.	Humus levels in soils; current thinking on the maintenance of organic matter in the soils.	2
4.	Carbon retention and sequestration.	2
5.	Humic substances: structure and concept	2
6.	Biochemistry of the humus formation	2
7.	Different pathways for humus synthesis in soil	3
8.	Soil carbohydrates and lipids.	2
9.	Nutrient transformation of N and interaction with humic substances	2
10.	Nutrient transformation of P and interaction with humic substances	2
11.	Nutrient transformation of S and interaction with humic substances.	2
12.	Significance of chelation reactions in soils	2
13.	Reactive functional groups of humic substances	1
14.	Adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes	2
15.	Clay-organic matter complexes	2
16.	Humus - pesticide interactions in soil, mechanisms	2
Total		**32**

Suggested Readings

1. *LynchJM,WilleyJM.SoilBiotechnology.*
2. *PaulEA and Clark FE. Soil Microbiology and Biochemistry*
3. *SherwoodLMandWoolvertonCJ.Prescott'sMicrobiology.*
4. *SubbaRaoNS.AdvancesInAgriculturalMicrobiology*

SOIL 623 SOILRESOURCEMANAGEMENT 2(2+0)

Objectives

Toimpartthestudentsbasicholisticknowledgeonsoilresourceandlatestdevelopmentsinitssustainableuse.

Theory

UnitI

Relevance of soil management to sustainable agriculture; soil as a natural resourcefor biomass production, filtering, buffering, transportation of solutes, gene reserves,andgeogenicsourceofrawmaterials;soilasasourceand sink of greenhousegases.

UnitII

Concept of sustainable land management (SLM); spatial variability of soils; soilqualityandfoodsecurity;soilqualityindices,conservationagricultureinrelationtosoilquality;soilresilienceandresistance.

UnitIII

Types,factorsandcausesoflanddegradationanddesertification;GLASODclassification;applicationofGISandremotesensinginmonitoring,diagnosisandmappinglanddegradation;history,distribution,identificationanddescriptionofsoilerosionproblemsinIndia;formsofsoilerosion;impactofsoilerosion-on-siteandoff-siteeffects;strategiesforerosioncontrolandconservation;soilconservationinhilly,arid,semiarid,coastalanddiaralands.Managementofforest,peatandmucksoils.

UnitIV

Soil conservation planning; land capability classification; soil conservation in specialproblemareassuchashilly,aridandsemi-aridregions,waterloggedandwetlands;landrestorationandconservationtechniques–erosioncontrol,reclamationofsalt affectedsoils;minelandreclamation,afforestation,organicproducts,soilfaunaandbiodegradation.

UnitV

Watershedmanagement-concept,objectivesandapproach;waterharvestingandrecycling;floodcontrolinwatershedmanagement;socio-economicaspectsofwatershedmanagement;casestudiesinrespecttomonitoringandevaluationofwatersheds.

UnitVI

Agro-ecologicalregionsofIndia;potentialsandconstraintsofsoilsofdifferentregions;landevaluationandrationalizinglanduse,decisionsupportsystemwithrelationtolandmanagement;nationalandinternationalsoilpolicyconsiderations.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Relevance of soil management to sustainable agriculture	1
2.	Soil as a natural resourcefor biomass production, filtering, buffering, transportation of solutes, gene reserves,andgeogenicsourceofrawmaterials	2
3.	Soilasasourceand sink of greenhousegases	1
4.	Concept of sustainable land management (SLM)	1
5.	Spatial variability of soils	1
6.	Soilqualityandfoodsecurity	1
7.	Soilqualityindices	1
8.	Conservationagricultureinrelationtosoilquality;soilresilienceandresistance.	2
9.	Types,factorsandcausesoflanddegradationanddesertification	1
10.	GLASODclassification	1
11.	ApplicationofGISandremotesensinginmonitoring,diagnosisandmappinglanddegradation	2
12.	History,distribution,identificationanddescriptionofsoilerosionproblemsinIndia	2
13.	Formsofsoilerosion;impactofsoilerosion-on-siteandoff-siteeffects	2
14.	Strategiesforerosioncontrolandconservation;soilconservationinhilly,arid,semiarid,coastalanddry lands.Managementofforest,peatandmucksoils	2
15.	Soil conservation planning; land capability classification; soil conservation in specialproblemareassuchashilly,aridandsemi-aridregions,waterloggedandwetlands	2
16.	Landrestorationandconservationtechniques–erosioncontrol,reclamationofsalt affectedsoils;minelandreclamation,afforestation,organicproducts,soilfaunaandbiodegradation.	2
17.	Watershedmanagement-concept,objectivesandapproach	1
18.	Waterharvestingandrecycling;floodcontrolinwatershedmanagement; socio-economicaspectsofwatershed management	2
19.	Casestudiesinrespecttomonitoringandevaluationofwatersheds.	1
20.	Agro-ecologicalregionsofIndia; potentialsandconstraintsofsoilsofdifferentregions	2
21.	Landevaluationandrationalizinglanduse,decisionsupportsystemwithrelationtolandmanagement;nationalandinternationalsoilpolicyconsiderations.	2
Total		**32**

SuggestedReadings

1. *Abrol IP and Dhruvanarayana VV. 1990. Technology for Wasteland Development. ICAR,NewDelhi.*
2. *Andriesse JP. 1988. Nature and Management of Tropical Peat Soils, Soil Resources, FAOSoils Bulletin 59, Management and Conservation Service,*

Land and Water DevelopmentDivision,FAO,Rome

3. *Blackwell, Dent D and Young A. 1981. Soil Survey and Land Evaluation. George Allen andUnwin,London.*
4. *BurroughAandMcDonnellRK.1998.PrinciplesofGeographicalInformationSystem. Oxford UniversityPress.*
5. *DanBinkleyDandFisherR.2012.EcologyandManagementofForestSoils,4thEdition,Wiley.*
6. *FAO.1996.LandQualityIndicatorsandtheirUseinSustainableAgricultureandRuralDevelopment.FAOLandandWaterBulletin.5.FAO,Rome.*
7. *FaroqMandSiddiqueK.(Ed.).2015.ConservationAgriculture,SpringerNature,Chennai,India.*
8. *FESL. 1993. An International Framework for Evaluating Sustainable Land Management,FAOWorldSoilResourcesReportNo.73,LandDevelopmentDivision,FAO,Rome.*
9. *ISSS. 1994. ManagementofLandandWaterResourcesforSustainableAgricultureandEnvironment. Diamond Jubilee Symposium Publication, Indian Society of Soil Science, NewDelhi.*
10. *LalR,BlumWEH,ValentineCandStewartBA.(Editors).1988.MethodsforAssessmentof Soil Degradation.CRC Press,Boca Raton.*
11. *MuldersMA.1987.RemoteSensinginSoilScience.ElsevierSciencePublishers,Amsterdam.*
12. *SehgalJ.2014.ATextBookofPedologyConceptsandApplication.Kalyanipublishers,NewDelhi.*
13. *SSSA1996.MethodsforAssessingSoilQuality.SSSAPublicationNumber49,Madison, Wisconsin,USA.*

STATISTICS,MATHEMATICSANDCOMPUTER SCIENCE

The below mentioned courses are offered as minor and supporting courses in other disciplines. However, PG programme is not running in the department.

Course No.	Title	Credit Hrs.
STAT-511	STATISTICAL METHODS FOR APPLIED SCIENCES	2+1
STAT-521	EXPERIMENTAL DESIGNS	2+1
STAT-522	BASIC SAMPLING TECHNIQUES	2+1
STAT-523	DATA ANALYSIS USING STATISTICAL PACKAGES	2+1
STAT-524	APPLIED REGRESSION ANALYSIS	2+1
STAT-525	MATHEMATICS FOR APPLIED SCIENCES	3+0

STAT-511 STATISTICAL METHODS FOR APPLIED SCIENCES 3(2+1)

Objectives

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

Unit I

Descriptive statistics, Exploratory data analysis, Theoryof probability, Random variable andmathematical expectation.

Unit II

Discrete and continuous probability distributions, Binomial, Poisson, Normal Distribution and their applications.

Concept of sampling distribution: chi-square, t andF distributions. Tests of significance based on Normal, chi-square, tand F distributions.

Unit III

Introduction to theory of estimation and confidence-intervals, Simpleand multiplecorrelation coefficient, partial correlation, rankcorrelation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination.

Unit IV

Non-parametric tests - Sign, Run test for the randomness of a sequence, Median test.

Unit V

Introduction to ANOVA:One way and Two way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Descriptive Statistics& Exploratory data analysis	2
2.	Theory of probability	2
3.	Random variable and mathematical expectation	1
4.	Discrete and continuous probability distribution	1
5.	Binomial, Poisson, Normal distribution and their applications	3
6.	Concept of sampling distribution:chi-square, t and F distributions	3
7.	Tests of significance for Normal, chi-square, t and F distributions	2
8.	Introduction to theory of estimation and confidence-intervals	1
9.	Simple and multiple correlation coefficient, partial correlation	2
10.	Rank correlation	1
11.	Simple and multiple linear regression model	2
12.	Test of significance of correlation coefficient and regressioncoefficients, Coefficient of determination	1
13.	Non-parametric tests-Concept and definition	1
14.	Sign, Run test for the randomness of a sequence, Median test	2
15.	Introduction to ANOVA: One way and Two Way	3
16.	Introduction to Sampling Techniques	2
17.	Introduction to Multivariate Analysis	2
18.	Transformationof Data	1
Total		**32**

Practical

- Exploratory data analysis, fitting of distributions: Binomial, Poisson, Normal.
- Large sample tests, testing of hypothesis based onexact sampling distributions, chi square, tand F.
- Confidence interval estimation and Correlationand regression analysis, fitting of Linear model.
- Non-parametric tests, ANOVA: One way, Two Way, SRS.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures

1.	Exploratory data analysis	1
2.	Fitting of Binomial distribution	1
3.	Fitting of Poisson distribution	1
4.	Fitting of Normal distribution	1
5.	Large Sample tests	1
6.	Chi Square test	1
7.	One sample, two sample and paired t test	1
8.	F- test	1
9.	Confidence interval estimation and Computation of Simple correlation & regression	1
10.	Computation of partial and multiple correlation	1
11.	Sign test	1
12.	Run test	1
13.	Median test	1
14.	One Way ANOVA	1
15.	Two Way ANOVA	1
16.	Simple Random Sampling	1
Total		**16**

Suggested Readings

1. *Goon A.M, Gupta M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.*
2. *Goon A.M, Gupta M.K. and Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. TheWorld Press.*
3. *Hoel P.G. 1971. Introduction to Mathematical Statistics. John Wiley.*
4. *Hogg R.V and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.*
5. *Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.*
6. *Hogg RV, McKean JW, Craig AT. 2012. Introduction to Mathematical Statistics 7th Edition.*
7. *Siegel S, Johan N &Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. JohnWiley.*
8. *Anderson W. 2009. An Introduction to Multivariate Statistical Analysis, 3rd Ed. John Wiley*

STAT521 EXPERIMENTAL DESIGNS 3(2+1)

Objectives

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and theirapplications, Responsesurfaces, Combined analysis.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Basic concepts of design of experiment	2
2.	Terminology and characteristics of a good design	1
3.	Basic principles of designs- randomization, replication and local control	1
4.	Uniformity trials	1
5.	Size and shape of plots and blocks	1
6.	Analysis of variance	2
7.	CRD, RBD and LSD	3
8.	Factorial experiments- symmetrical and asymmetrical	4
9.	Orthogonality and partitioningof degrees of freedom.	1
10.	Confounding	2
11.	Split plot design	2
12.	Strip plot design	2
13.	Analysis of covariance and missing plot techniques (in RBD and LSD)	2
14.	Transformations	1
15.	Balanced Incomplete Block Design	2
16.	Resolvable designs and their applications	1
17.	Response surfaces	2
18.	Combined analysis	2
Total		**32**

Practical

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
- Analysis with missing data,

- Split plot and strip plot designs.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Uniformity trial data analysis	1
2.	Formation of plots and blocks and Fairfield Smith law	1
3.	Analysis of CRD	1
4.	Analysis of RBD	1
5.	Analysis of LSD	1
6.	Analysis of factorial experiment	1
7.	Analysis of asymmetric factorial experiments	1
8.	Analysis of confounded factorial experiments	1
9.	Analysis with missing data in RBD	1
10.	Analysis with missing data in LSD	1
11.	Transformation of data	1
12.	Analysis of SPD	1
13.	Analysis of strip plot design	1
14.	Analysis of resolvable designs	1
15.	Fitting of response surfaces	2
Total		**16**

Suggested Readings

1. *Cochran WGand Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.*
2. *Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.*
3. *Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.*
4. *Federer WT. 1985. Experimental Designs. MacMillan.*
5. *Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.*
6. *Nigam AK and Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments.IASRI Publ.*
7. *Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. www.drs.icar.gov.in.*

STAT 522BASIC SAMPLING TECHNIQUES 3(2+1)

Objectives

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

Theory

Unit I

Concept of sampling, sample survey vs completeenumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, Systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and Regression estimators.Double Sampling, sampling and non-sampling errors.

Lecture Schedule- Theory

S. No.	Topics	No. of Lectures
1.	Concept of sampling and terminology	2
2.	Sample survey vs complete enumeration	2
3.	Planning of sample survey	1
4.	Sampling from a finite population	2
5.	Simple random sampling with and without replacement	2
6.	Sampling for proportion	1
7.	Determination of sample size	1
8.	Inverse sampling	1
9.	Stratified sampling	3
10.	Systematic sampling	2
11.	Cluster sampling	2
12.	Multi-stage sampling	2
13.	PPS sampling	2
14.	Use of auxiliary information in estimation	1
15.	Ratio and regression estimators	2
16.	Double sampling	1
17.	Sampling and non-sampling errors	3
18.	Preparation of questionnaire	2
Total		**32**

Practical

- Random sampling, use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures

1.	Random sampling, use of random number tables	2
2.	Concepts of unbiasedness, variance, etc	2
3.	Determination of sample size in (SRS, Stratified sampling)	2
4.	Estimation of mean and variance in simple random sampling	2
5.	Inverse sampling	1
6.	Stratified sampling	1
7.	Cluster sampling	1
8.	Systematic sampling	1
9.	Estimation using Ratio estimator	1
10.	Estimation using Regression estimator	1
11.	Estimation using Multi stage sampling	1
12.	Estimation using Double sampling	1
Total		**16**

SuggestedReadings

1. Cochran WG.1977.Sampling Techniques. John Wiley.
2. Murthy M N. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ.Soc., Calcutta.
3. Singh D, Singh PandKumar P.1982.Handbook on Sampling Methods. IASRI Publ.
4. Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C.1984. Sampling Theory of Surveys with Applications.Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
5. Cochran WG.2007. Sampling Techniques, 3rd Edition. John Wiley &Sons Publication

STAT- 523 DATA ANALYSIS USING STATISTICAL PACKAGES 3(2+1)

Objectives

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

Unit I

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit II

Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.

Unit III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

Unit IV

Analysis of mixed models; Estimationof variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Lecture Schedule-Theory

S. No.	Topics	No of Lectures
1.	Introduction and uses of software packages- Excel, R, SAS, SPSS	2
2.	Data Preparation -Summarization and tabulation of data	1
3.	Descriptive statistics	2
4.	Graphical representation of data, Exploratory data analysis	1
5.	Test of normality	1
6.	Testing of hypothesis usingchi-square test	2
7.	Testing of hypothesis using t and F statistics	2
8.	Testing of hypothesis using Z-test	1
9.	Analysis of Variance	1
10.	Analysis of Covariance	1
11.	Factorial Experiments, contrast analysis, multiple comparisons	2
12.	Analyzing crossedand nestedclassified designs	2
13.	Analysis of mixedmodels	1
14.	Estimation of variance components	2
15.	Correlation and regression analysis	2
16.	Probit, Logit and Tobit Models	2
17.	Discriminant function analysis	1
18.	Factor analysis, Principal Component Analysis	2
19.	Analysis of time series data	1
20.	Fitting of non-linear models	2
21.	Neural network	1
Total		**32**

Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples- Chi-squares test, Ftest, one-way analysis of variance;

- Designs for Factorial Experiments, fixed effect models, random effect models, mixedeffect models, estimation ofvariance components;
- Linear regression, Multiple regression, Regression plots;
- Discriminant analysis - fitting ofdiscriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

Lecture Schedule-Practical

S. No.	Topics	No. of Lectures
1.	Summarization and tabulation of data	1
2.	Obtaining descriptive statistics	1
3.	Graphical representation of data	1
4.	Test of normality, Testing the hypothesis for one sample t-test	1
5.	Testing the hypothesis for Two sample t-test and Paired t-test	1
6.	Test for large samples- Chi-squares test	1
7.	Test for large samples- Z test	1
8.	One-way analysis of variance	1
9.	Designs for Factorial Experiments, fixed effect models, random effect models, mixedeffect models	1
10.	Estimation of variance components	1
11.	Linear regression	1
12.	Multiple regression and Regression plots	1
13.	Discriminantanalysis- fitting ofdiscriminant functions, identification of important variables	1
14.	Factor Analysis; Principal component analysis - obtaining principal component	1
15.	Analysis of time series data	1
16.	Fitting of non-linear models	1
Total		**16**

Suggested Readings:

1. Anderson C.W. and LoynesR.M. 1987. The Teaching of Practical Statistics. John Wiley.

2. Atkinson A.C. 1985. Plots Transformations and Regression. Oxford University Press.

3. Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.

4. Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall.

5. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.

6. Cleveland W.S. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.

7. Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
8. Erickson B.H. and Nosanchuk T.A. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.
9. Snell E.J. and Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman and Hall.
10. Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
11. Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
12. Velleman PF and Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
13. Weisberg S. 1985. Applied Linear Regression. John Wiley.
14. Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall

STAT- 524 APPLIED REGRESSION ANALYSIS 3(2+1)

Objectives

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multicollinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

Unit I

Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

Unit II

Problem of correlated errors; Autocorrelation; Heteroscedastic models, Durbin WatsonStatistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

Unit III

Diagnostic of multiple regressionequation; Concept of weighted least squares; regression equation on groupeddata; Various methods of selecting the best regression equation.

Unit IV

Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures

1.	Correlation analysis, its measuresand Correlation from grouped data	3
2.	Rank correlation	1
3.	Testing of population correlation coefficients	1
4.	Multiple and partial correlation coefficients and their testing	2
5.	Problem of correlated errors; Auto correlation	1
6.	Heteroscedastic model, Durbin WatsonStatistics	2
7.	Removal of auto correlation by transformation	1
8.	Analysis of collinear data	1
9.	Detection and correction of multi collinearity	2
10.	Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients;	2
11.	Multiple and partial regressions	2
12.	Diagnostic of multiple regression equation	2
13.	Concept of weighted least squares	1
14.	Regression equation on grouped data	2
15.	Various methods of selectingthe bestregression equation	2
16.	Concept of nonlinear regression	1
17.	Fitting of quadratic, exponential and power curves	3
18.	Economic and optimal dose	1
19.	Orthogonal polynomial	2
Total		**32**

Practical

1. Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses;
2. Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and theirapplications in outlier detection;
3. Handling of correlated errors, multi collinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Lecture Schedule- Practical

S. No.	Topics	No. of Lectures
1.	Correlation coefficient and various types of correlation coefficient	2
2.	Partial and multiple correlation coefficients	2
3.	Testing of hypothesis for correlation coefficient	1
4.	Multiple Linear regression analysis	2
5.	Partial regression coefficients and their testing	2
6.	Residuals and theirapplications in outlier detection	1
7.	Handling of correlated errors, multi collinearity	1

8.	Fitting of quadratic curves	1
9.	Fitting of exponential and power curves	2
10.	Fitting of orthogonal polynomials	2
Total		**16**

Suggested Readings

1. *Kleinbaum DG, Kupper LL, Muller KE& Nizam A. 1998. Applied Regression Analysis and Multivariable Methods. Duxbury Press.*
2. *Draper NRand SmithH.1998.AppliedRegression Analysis.3rd Ed.John Wiley*
3. *Ezekiel M. 1963. Methods of Correlation and Regression Analysis. John Wiley.*
4. *Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan.*
5. *Kutner MH, Nachtsheim CJ &Neter J. 2004. Applied Linear Regression Models. 4th Ed. McGraw Hill.*

STAT-525MATHEMATICS FOR APPLIED SCIENCES 3(3+0)

Objectives

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to Linear Algebra, differentiation, integration and differential equation etc.

Theory:

Unit I

Set theory-set operations, finite and infinite sets, operations of set, function.

Unit II

Vectors and vector spaces, Matrices notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and Eigen vectors. Determinants - evaluation and properties of determinants, Solution of Linear Equations.

Unit III

Variables and functions; limit and continuity of Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, Differentiation of function of a function, derivative of higher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

Unit IV

Integration, methods of integration, reduction formulae, definite and indefinite integral, Applications of integration in agriculture, Differential Equations: order and degree. Classification as ordinary and partial differential equations. Solution of simple problems of the type $\frac{dy}{dx} = f(x)$ using integration technique.

Suggested Readings

1. *Hohn FE. 2013. Elementary Matrix Algebra, 3rd Edition. Kindle Edition.*
2. *Harville DA. 1997. Matrix Algebra from a Statistician's Perspective. Springer.*
3. *Hohn FE. 1973. Elementary Matrix Algebra. Macmillan.*

4. *Searle SR. 1982. Matrix Algebra Useful for Statistics. John Wiley.*
5. *Stewart J. 2007. Calculus. Thompson.*
6. *Thomas GB. Jr. & Finney RL. 1996. Calculus. 9th Ed. Pearson Edu.*

Lecture Schedule-Theory

S. No.	Topics	No. of Lectures
1.	Set Theory	1
2.	Set operations	1
3.	Finite and infinite sets	1
4.	Function	1
5.	Vectors	1
6.	Matrix notation, Matrix Addition	1
7.	equality of matrices, square matrix, identity, null matrix	1
8.	Subtraction, Scalar Multiplication,	1
9.	Matrix Multiplication, Transpose of a Matrix	1
10.	Eigen Values and Eigen Vectors	2
11.	Determinants 2*2, 3*3	1
12.	Properties of determinants	2
13.	Cramer's rule for solving system of linear equations	2
14.	Variables, Functions, Evaluation of Functions, Operations with functions	3
15.	Indeterminate forms and Limits, $\lim_{x\to a}\frac{x^n-a^n}{x-a}$,	2
16.	Limits $\lim_{x\to 0}\frac{\sin x}{x}$, $\lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$	2
17.	Continuity	1
18.	Differentiation of elementary functions	1
19.	differentiation of sum and product of functions	2
20.	Quotient rule, function of functions	2
21.	Differentiation of function of functions,	3
22.	Successive differentiation	1
23.	Partial derivatives	1
24.	Maxima and minima	2
25.	Determination of point of inflexion	1
26.	Integration	1
27.	Integration Formulae	1
28.	Integration by Substitution	2
29.	Integration by Parts	2
30.	Reduction Formulae	2
31.	Definite Integration	1
32.	Differential Equations: order and degree. Classification	1

	as ordinary and partial differential equations.	
33.	Solution of simple problems of the type $\frac{dy}{dx} = f(x)$ using integration technique.	1
Total		**48**

HORTICULTURE:VEGETABLE SCIENCE

Semester Wise Course Distribution

S. No.	Course No.	Title	Credit Hrs
M.Sc. (Hort.) Vegetable Science Semester-I			
1	**VSC 511**	**PRODUCTION OF COOL SEASON**	**3(2+1)**

		VEGETABLE CROPS	
2	**VSC512**	**GROWTH AND DEVELOPMENT OF VEGETABLE CROPS**	**3(2+1)**
3	**VSC 513**	**PROTECTED CULTIVTION OF VEGETABLES CROPS**	**2(1+1)**
Minor Courses			
4	**GPB-513/ GPB-514**	**SEED PRODUCTION AND CERTIFICATION/VARIETAL DEVELOPMENT AND MAINTENANCE BREEDING**	**2(1+1)/ 2(1+1)**
Supporting Courses			
5	**STAT-511**	**STATISTICAL METHOD FOR APPLIED SCIENCES**	**3(2+1)**
Common Courses			
6	**PGS-511**	**LIBRARY AND INFORMATION SERVICES**	**1(0+1)**
Total			**14**
Semester- II			
1	**VSC 521**	**PRODUCTION OF WARM SEASON VEGETABLES CROPS**	**3(2+1)**
2	**VSC522**	**PRINCIPLES OF VEGETABLE BREEDING**	**3(2+1)**
3	**VSC 523**	**BREEDING OF CROSS POLLINATED VEGETABLES CROPS**	**3(2+1)**
Minor Courses			
4	**PPHYS-522/ PPHYS-521**	**PLANT DEVELOPMENT BIOLOGY: PHYSIOLOGICAL AND MOLECULAR BASIS/PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES**	**3(2+1)/ 3(2+1)**
Supporting Courses			
5	**STAT-521**	**EXPERIMENTAL DESIGN**	**3(2+1)**
Semester- III			
1	**VSC 531**	**SEED PRODUCTION OF VEGETABLE CROPS**	**3(2+1)**
Minor Courses			
2	**PPATH-532**	**DISEASES OF FRUITS, VEGETABLES,PLANTATION AND ORNAMENTAL CROPS**	**3(2+1)**
Common Courses			
3	**PGS -531**	**TECHNICAL WRITING AND COMMUNICATION SKILLS**	**1(0+1)**
4	**PGS-532**	**INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**	**1(1+0)**
5	**PGS-533**	**BASIC CONCEPTS IN LABORATORY TECHNIQUES**	**1(0+1)**
6	**PGS-534**	**AGRICULTURE RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES**	**1(1+0)**
Total			**10**
7	**VSC 543**	**RESEARCH**	**30**

Semester IV			
1	**VSC 541**	**SEMINAR**	**1 (1+0)**
2	**VSC 542**	**COMPREHENSIVE**	**NC**
3	**VSC 543**	**RESEARCH BY THESIS (THIRD SEMESTER ONWARDS)**	**30**
Non Core Courses (MAY BE OPTED IN FUTURE)			
1	**VSC 514**	**SYSTEMATICS OF VEGETABLE CROPS**	**2(1+1)**
2	**VSC 524**	**ORGANIC VEGETABLE PRODUCTION**	**2(1+1)**
3	**VSC 534**	**PROCESSING OF VEGETABLES**	**2(1+1)**
4	**VSC 515**	**PRODUCTION OF SPICE CROPS**	**3(2+1)**
5	**VSC 532**	**PRODUCTION OF UNDERUTILIZED VEGETABLE CRIOPS**	**3(2+1)**
6	**VSC 533**	**BREEDING OF SELF POLLINATED VEGETABLE CROPS**	**3(2+1)**
7	**VSC 535**	**POSTHARVEST MANAGEMENT OF VEGETABLES CROPS**	**3(2+1)**
Ph.D.(Hort.) Vegetable Science Semester-I			
1	**VSC611**	**RECENT TRENDS IN VEGETABLE PRODUCTION**	**3(3+0)**
2	**VSC612**	**ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS**	**3(2+1)**
Minor Courses			
3	**GPB-512**	**PRINCIPLES OF PLANT BREEDING**	**3(2+1)**
Supporting Courses			
4	**ENT-513**	**CONCEPTS OF INTEGRATED PEST MANAGEMENT**	**2 (2+0)**
Total			**11**
Semester-II			
1	**VSC 621**	**ADVANCES IN BREEDING OF VEGETABLE CROPS**	**3(3+0)**
2	**VSC622**	**SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLESCROPS**	**3(2+1)**
Minor Courses			
3	**PPHYS-523**	**SEED PHYSIOLOGY**	**3(2+1)**
Supporting Courses			
4	**STAT-521/BIOCHEM-521**	**EXPERIMENTAL DESIGN/BASIC BIOCHEMISTRY**	**3(2+1)/ 3(2+1)**
Total			**12**
Semester III and Onward			
1	**VSC 641**	**DOCTORAL SEMINAR I**	**1 (1+0)**
2	**VSC 642**	**DOCTORAL SEMINAR II**	**1 (1+0)**
3	**VSC 643**	**COMPREHENSIVE**	**NC**
4	**VSC 644**	**DOCTORAL RESEARCH**	**75**
Non Core Courses (Ph.D.) Programme (MAY BE OPTED IN FUTURE)			
1	**VSC-613**	**BIODIVERSITY AND CONSERVATION OF VEGETABLE CROPS**	**3(2+1)**

2	**VSC-614**	**BIOTECHNOLOGICAL APPROACHES IN VEGETABLE CROPS**	**3(2+1)**
3	**VSC-624**	**ADVANCED LABORATORY TECHNIQUES FOR VEGETABLES CROPS**	**3(1+2)**
4	**VSC-623**	**BREEDING FOR SPECIAL TRAITSIN VEGETABLE CROPS**	**2(2+0)**

Non core courses adopted and approved in BoS,out of which one or more courses may be opted in future as and when need arise.

M.Sc.(Ag.) Programme

VSC 511 PRODUCTION OF COOL SEASONVEGETABLE CROPS 3(2+1)

Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery, sowing/planting time and methods, hydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Lecture Schedule-Theory

S.No.	Topics	No.of Lectures
1	Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery, sowing/planting time and methods, hydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of Potato	3
2	Onion	3
3	Garlic	2
4	Cabbage	2
5	Cauliflower	3

6	Kohlrabi	1
7	Broccoli	2
8	Brussels sprouts and kale	1
9	Carrot	2
10	Radish	2
11	Turnip	1
12	Beetroot	1
13	Garden peas	2
14	Broad bean	1
15	Beet leaf	1
16	fenugreek	1
17	Coriander	1
18	Lettuce	1
19	Spinach	1
20	Bathua	1
Total		**32**

Practical

Scientific raising of nursery and seed treatment. Sowing and transplanting. Description of commercial varieties and hybrids.Demonstration on methods of irrigation, fertilizers and micronutrients application. Mulching practices, weed management. Use of plant growth substances in cool season vegetable crops. Study of nutritional and physiological disorders. Studies on hydroponics, aeroponics and other soilless culture. Identification of important pest and diseases and their control. Preparation of cropping scheme for commercial farms. Visit to commercial farm, greenhouse/polyhouses. Visit to vegetable market. Analysis of benefit to cost ratio

Lecture schedule- Practical

S.No.	Topics	No. of Lectures
1	Scientific raising of nursery and seed treatment	2
2	Sowing and transplanting	2
3	Demonstration on methods of irrigation, fertilizers and micronutrients application	1
4	Description of commercial varieties and hybrids	2
5	Mulching practices, weed management	1
6	Use of plant growth substances in cool season vegetable crops	1
7	Study of nutritional and physiological disorders	1
8	Studies on hydroponics, aeroponics and other soilless culture	1
9	Identification of important pest and diseases and their control	1
10	Preparation of cropping scheme for commercial farms	1
11	Visit to commercial farm, greenhouse/polyhouses	1

12	Visit to vegetable market	1
13	Analysis of benefit to cost ratio	1
Total		**16**

Suggested Readings:

1. *Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003. Vegetable crops. Vols. I-III. Nayaudyog.*
2. *Bose, T.K., Som, M.G. and Kabir, J. (Eds.). 1993. Vegetable crops. Nayaprokash.*
3. *Chadha, K.L. and Kalloo, G. (Eds.), 1993-94. Advances in horticulture Vols. V-X. Malhotra publ. house.*
4. *Chadha, K.L. (Ed.), 2002. Hand book of horticulture. ICAR.*
5. *Chauhan, D.V.S. (Ed.), 1986. Vegetable production in India. Ram prasad and sons.*
6. *Fageria, M.S., Choudhary, B.R. and Dhaka, R.S., 2000, Vegetable crops: production technology. Vol. II. Kalyani publishers.*
7. *Gopalakrishanan, T.R., 2007, Vegetable crops. New India publ. agency.*
8. *Hazra, P. and Banerjee M.K. and Chattopadhyay, A., 2012, Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana, 199 p*
9. *Hazra, P., 2016, Vegetable science. 2ndedn, Kalyani publishers, Ludhiana.*
10. *Hazra, P., 2019, Vegetable production and technology. New India publishing agency, New Delhi.*
11. *Hazra, P., Chattopadhyay, A., Karmakar K. and Dutta, S., 2011, Modern technology for vegetable production, New India publishing agency, New Delhi, 413p*
12. *Rana, M,K., 2008, Olericulture in India. Kalyani Publication.*
13. *Rana, M.K., 2008, Scientific cultivation of vegetables. Kalyani Publication.*
14. *Rana, M.K., 2014, Technology for vegetable production. Kalyani publishers, New Delhi.*
15. *Rubatzky, V.E. and Yamaguchi, M. (Eds.), 1997, World vegetables: principles, production and nutritive values. Chapman and Hall.*
16. *Saini, G.S., 2001, A text book of Oleri and Floriculture. Aman publishing house.*
17. *Salunkhe, D.K. and Kadam, S.S. (Ed.), 1998, Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.*
18. *Shanmugavelu, K.G., 1989, Production technology of vegetable crops. Oxford and IBH.*
19. *Singh, D.K., 2007, Modern vegetable varieties and production technology. International book distributing Co.*
20. *Singh, S.P. (Ed.), 1989, Production technology of vegetable crops. Agril. Comm. Res. Centre.*
21. *Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR.*
22. *Thompson, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.*

VSC-512 GROWTH AND DEVELOPMENT OF VEGETABLE CROPS 3(2+1)

Theory

Definition of growth and development; Cellular structures and their functions; Physiology of phyto-hormones functioning/biosynthesis and mode of action; Growth analysis and its importance in vegetable production

Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of

action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production

Impact of light, temperature, photoperiod, carbon dioxide, oxygen and other gases on growth, development of underground parts, flowering and sex expression in vegetable crops; Apical dominance

Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening

Morphogenesis and tissue culture techniques in vegetable crops; Grafting techniques in different vegetable crops

Lecture Schedule-Theory

S.No.	Topics	No.of Lectures
1	Introduction and phytohormones- Definition of growth and development	2
2	Cellular structures and their functions	1
3	Physiology of phyto-hormones functioning/biosynthesis and mode of action	2
4	Growth analysis and its importance in vegetable production	2
5	Physiology of dormancy and germination of vegetable seeds, tubers and bulbs.	2
6	Role of auxins, gibberellilns, cyktokinins and abscissic acid	3
7	Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops;	2
8	Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production	2
9	Impact of light, temperature and Photoperiod,	2
10	Carbon dioxide, oxygen and other gases on growth,	2
11	Development of underground parts, flowering and sex expression in vegetable crops	2
12	Apical dominance	1
13	Physiology of fruit set and Fruit development	2
14	Fruit growth, flower and fruit drop	1
15	Parthenocarpy in vegetable crops	1
16	Phototropism, ethylene inhibitors, senescence and abscission	1
17	Fruit ripening and physiological changes associated with ripening	1
18	Morphogenesis and tissue culture- Morphogenesis and tissue culture techniques in vegetable crops;	2
19	Grafting techniques in different vegetable crops	1

Total	**32**

Practical

Preparation of plant growth regulator's solutions and their application. Experiments in breaking and induction of dormancy by chemicals. Induction of parthenocarpy and fruit ripening. Application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables. Growth analysis techniques in vegetable crops. Grafting techniques in tomato, brinjal, cucumber and sweet pepper.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Preparation of plant growth regulator's solutions and their application	2
2	Experiments in breaking and induction of dormancy by chemicals	2
3	Induction of parthenocarpy and fruit ripening	2
4	Application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables	3
5	Growth analysis techniques in vegetable crops	3
6	Grafting techniques in tomato, brinjal, cucumber and sweet pepper	4
Total		**16**

Suggested Readings:

1. *Bleasdale, J.K.A., 1984, Plant physiology in relation to horticulture (2nd Edition) MacMillan.*
2. *Gupta, U.S., Eds., 1978, Crop physiology. Oxford and IBH, New Delhi.*
3. *Kalloo, G. 2017. Vegetable grafting: Principles and practices. CAB International*
4. *Krishnamoorti, H.N., 1981, Application growth substances and their uses in agriculture. Tata McGraw Hill, New Delhi.*
5. *Leopold, A.C. and Kriedemann, P. E., 1981,Plant growth and development, Tata McGrawHill,New Delhi.*
6. *Peter, K.V. and Hazra, P. (Eds), 2012,Hand book of vegetables.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p*
7. *Peter, K.V., (Eds), 2008, Basics of horticulture. New India publication agency, New Delhi.*
8. *Rana, M.K., 2011. Physio-biochemistry and Biotechnology of Vegetables. New India Publishing Agency, Pritam Pura, New Delhi.*
9. *Saini et al. (Eds.), 2001, Laboratory manual of analytical techniques in horticulture. Agrobios, Jodhpur.*
10. *Wien, H.C. (Eds.), 1997, The physiology of vegetable crops. CAB International.*

VSC- 513 PROTECTED CULTIVATION OF VEGETABLE CROPS3(2+1)

Theory

Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/greenhouse structures

Classification and types of protected structures-greenhouse/polyhouses, plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation, insect proof net houses, shed net houses, rain shelters, NVP, climate control greenhouses, hydroponics and aeroponics. Soil and soilless media for bed preparation; Design and installation of drip irrigation and fertigation system

Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.

Nursery raising- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation

Cultivation of crops- Regulation of flowering and fruiting in vegetable crops. Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures

Solutions to problems- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Scope and importance- Concept, scope and importance of protected cultivation of vegetable crops	2
2	Principles, design, orientation of structure, low and high cost polyhouses/greenhouse structures	2
3	Types of protected structure- Classification and types of protected structures-greenhouse/polyhouses,	2
4	Plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation	2
5	Insect proof net houses, shed net houses, rain shelters, NVP and climate control greenhouses	2
6	hydroponics and aeroponics;	2
7	Soil and soilless media for bed preparation	2
8	Design and installation of drip irrigation and fertigation system	2
9	Abiotic factors- Effect of environmental factors and manipulation of temperature, light. Carbon dioxide, humidity, etc. on growth and yield of different vegetables.	2
10	Nursery raising- High tech vegetable nursery raising in	2

	protected structures using plugs and portrays	
11	Different media for growing nursery under protected cultivation	1
12	Nursery problems and management technologies including fertigation	2
13	Cultivation of crops- Regulation of flowering and fruiting in vegetable crops	1
14	Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures,	2
15	Varieties and hybrids, training, pruning and staking in growing vegetables under protected structures	2
16	Problems of growing vegetables in protected structures and their remedies,	2
17	Physiological disorders, insect and disease management in protected structures	1
18	Use of protected structures for seed production; Economics of greenhouse crop production	1
Total		**32**

Practical

Study of various types of protected structure. Study of different methods to control temperature, carbon dioxide and light. Study of different types of growing media, training and pruning systems in greenhouse crops. Study of fertigation and nutrient management under protected structures. Study of insect pests and diseases in greenhouse and its control. Use of protected structures in hybrid seed production of vegetables. Economics of protected cultivation (Any one crop). Visit to established green/polyhouses/shade net houses in the region

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Study of various types of protected structures for vegetable production	2
2	Study of different methods to control temperature, carbon dioxide and light	2
3	Study of different types of growing media	1
4	Training and pruning systems in greenhouse vegetable crops	2
5	Study of fertigation and nutrient management under protected structures	2
6	Study of insect, pests and diseases in greenhouse and its control	2
7	Use of protected structures in hybrid seed production of vegetables	2
8	Economics of protected cultivation (Any one crop)	1

9	Visit to established green/polyhouses/shade net houses in the region	2
Total		**16**

Suggested Readings:

1. *Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances inhorticulture. Malhotra Pub. House.*
2. *Chandra, S. and Som, V., 2000, Cultivating vegetables in green house. Indian horticulture 45:17-18.*
3. *Kalloo, G. and Singh, K. (Eds.), 2000, Emerging scenario in vegetable research and development.Research periodicals and Book publ. house.*
4. *Parvatha, R. P., 2016, Sustainable crop protection under protected cultivation. E-Book Springer.*
5. *Prasad, S. and Kumar, U., 2005, Greenhouse management for horticultural crops. 2nd Ed.Agrobios.*
6. *Resh, H.M., 2012, Hydroponic food production. 7thEdn. CRC Press.*
7. *Singh, B., 2005, Protected cultivation of vegetable crops. Kalyani publishers, New Delhi*
8. *Singh, D.K. and Peter, K.V., 2014, Protected cultivation of horticultural crops (1st Edition) New India publishing agency, New Delhi.*
9. *Singh, S., Singh, B. and Sabir, N., 2014, Advances in protected cultivation. New India publishing agency, New Delhi.*
10. *Tiwari, G.N., 2003, Green house technology for controlled environment. Narosa publ. house.*

VSC- 521 PRODUCTION OF WARM SEASON VEGETABLE CROPS (2+1)

Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of crops.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production,	3

	productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of Tomato	
2	Brinjal	3
3	Hot pepper	2
4	Sweet pepper	2
5	Okra	2
6	French bean	1
7	Indian bean (Sem)	1
8	Cluster bean	1
9	Cowpea	1
10	Cucumber	1
11	Melons	3
12	Gourds	3
13	Sweet potato	1
14	Elephant foot yam	1
15	Tapioca	1
16	Taro and yam	2
17	Pumpkin	1
18	Squashes	1
19	Amaranth	1
20	Drumstick	1
Total		**32**

Practical

Scientific raising of nursery and seed treatment. Sowing, transplanting, vegetable grafting. Description of commercial varieties and hybrids. Demonstration on methods of irrigation, fertilizers and micronutrients application. Mulching practices, weed management. Use of plant growth substances in warm season vegetable crops. Study of nutritional and physiological disorders. Studies on hydroponics, aeroponics and other soilless culture.Identification of important pest and diseases and their control. Preparation of cropping scheme for commercial farms. Visit to commercial farm, greenhouse/polyhouses. Visit to vegetable market. Analysis of benefit to cost ratio

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Scientific raising of nursery and seed treatment for vegetable crops	2
2	Sowing and transplanting	1
3	Description of commercial varieties and hybrids	2
4	Demonstration on methods of irrigation, fertilizers and micronutrients application	2
5	Mulching practices, weed management	1
6	Use of plant growth substances in cool season vegetable crops	1
7	Study of nutritional and physiological disorders	1
8	Studies on hydroponics, aeroponics and other soilless culture	1
9	Identification of important pest and diseases and their control	1
10	Preparation of cropping scheme for commercial farms	1
11	Visit to commercial farm, greenhouse/polyhouses	1
12	Visit to vegetable market	1
13	Analysis of benefit to cost ratio	1
Total		**16**

Suggested Readings:

1. *Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003, Vegetable crops. Vols. I-III. Nayaudyog.*
2. *Bose, T.K., Som, M.G. and Kabir, J. (Eds.), 1993, Vegetable crops. Naya Prakash.*
3. *Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances in horticulture Vols. V-X. Malhotra publ. house.*
4. *Chadha, K.L. (Ed.), 2002, Hand book of horticulture. ICAR.*
5. *Chauhan, D.V.S. (Ed.), 1986, Vegetable production in India. Ram prasad and Sons.*
6. *Fageria, M.S., Choudhary, B.R. and Dhaka, R.S., 2000, Vegetable crops: production technology. Vol. II. Kalyani.*
7. *Gopalakrishanan, T.R., 2007, Vegetable crops. New India publ. agency.*
8. *Hazra, P. and Banerjee, M. K. and Chattopadhyay, A. (2012), Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana.*
9. *Hazra, P., 2016, Vegetable science. 2ndedn, Kalyani publishers, Ludhiana.*
10. *Hazra, P., 2019, Vegetable production and technology. New India publishing agency, New Delhi.*
11. *Hazra, P., Chattopadhyay, A., Karmakar, K. and Dutta, S., (2011),Modern technology for vegetable production, New India publishing agency, New Delhi,*
12. *Rana, M.K., 2008, Olericulture in India. Kalyani Publication.*
13. *Rana, M.K., 2008, Scientific cultivation of vegetables. Kalyani Publication.*
14. *Rubatzky, V.E. and Yamaguchi, M. (Eds.), 1997, World vegetables: principles, production and nutritive values. Chapman and Hall.*
15. *Saini, G.S., 2001, A text book of oleri and flori culture. Aman publishing house.*

16. *Salunkhe, D.K. and Kadam, S.S. (Ed.), 1998, Hand book of vegetable science andtechnology: production, composition, storage and processing. Marcel dekker.*
17. *Shanmugavelu, K.G., 1989, Production technology of vegetable crops. Oxford and IBH.*
18. *Singh, D.K., 2007, Modern vegetable varieties and production technology. International book distributing Co.*
19. *Singh, S.P. (Ed.), 1989, Production technology of vegetable crops. Agril. Comm. Res. Centre.*
20. *Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR.*
21. *Thompson, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.*

VSC-522 PRINCIPLES OF VEGETABLE BREEDING3(2+1)

Theory

Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding. Techniques of selfing and crossing, Breeding systems and methods, Selection procedures and hybridization, Genetic architecture, Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE). Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms. Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment. Ideotype breeding, varietal release procedure, DUS testing in vegetable crops, Application of *In-vitro* and molecular techniques in vegetable improvement.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Importance, history of vegetable breeding	2
2	Evolutionary aspects of vegetable breeding, Its variation from cereal crop breeding	2
3	Techniques of selfing and crossing	2
4	Breeding systems and methods; Selection procedures	2
5	Hybridization; Genetic architecture	2
6	Breeding for biotic stress (diseases, insect pests and nematode)	2
7	Abiotic stress (temperature, moisture and salt) resistance	2
8	Quality improvement; Breeding for water use efficiency (WUE)	1
9	Nutrients use efficiency (NUE)	1
10	Types, mechanisms and basis of heterosis	2
11	Facilitating mechanisms like male sterility	2
12	Self-incompatibility and sex forms	2
13	Mutation and Polyploidy breeding	2
14	Improvement of asexually propagated vegetable crops	1
15	Vegetables suitable for protected environment	1

16	Ideotype breeding	1
17	Varietal release procedure	2
18	DUS testing in vegetable crops, Application of *In-vitro*	1
19	Molecular techniques in vegetable improvement	2
Total		**32**

Practical

Floral biology and pollination behaviour of different vegetables. Techniques of selfing and crossing of different vegetables viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc. Breeding system and handling of filial generations of different vegetables. Exposure to biotechnological lab practices. Visit to breeding farms

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Floral biology and pollination behaviour of different vegetables	4
2	Techniques of selfing and crossing of different vegetables viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.	4
3	Breeding system and handling of filial generations of different vegetables	4
4	Exposure to biotechnological lab practices.	3
5	Visit to breeding farms	1
Total		**16**

Suggested Readings:

1. *Allard, R.W., 1960, Principle of plant breeding. John Willey and Sons, USA.*
2. *Kalloo, G., 1988, Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.*
3. *Kole, C.R. 2007, Genome mapping and molecular breeding in plants-vegetables. Springer, USA.*
4. *Peter, K.V. and Pradeep Kumar, T., 1998, Genetics and breeding of vegetables. ICAR, New Delhi, p. 488*
5. *Prohens, J. and Nuez, F., 2007, Handbook of plant breeding-vegetables (Vol I and II). Springer,USA.*
6. *Singh, B.D., 2007, Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.*
7. *Singh, Ram J., 2007, Genetic resources, chromosome engineering, and cropimprovement-vegetable crops(Vol. 3). CRC Press, Fl, USA.*

VSC-523BREEDING OF CROSS-POLLINATED VEGETABLE CROPS 3(2+1)

Theory

Origin, botany, taxonomy, cytogenetics, genetics, types of pollination and fertilization, mechanism, sterility and incompatibility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation, polyploidy), varieties and varietal characterization,

resistance breeding for biotic and abiotic stresses, quality improvement, molecular markers and marker assisted breeding, and QTLs, PPV and FR act of
Cucurbitaceous crops- Gourds, melons, cucumber, pumpkin and squashes.
Cole crops- Cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts.
Root and bulb crops- Carrot, radish, turnip, beet root and onion.
Tuber crops- Sweet potato, tapioca, taro and yam.
Leafy vegetables- Beet leaf, spinach, amaranth and coriander.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Origin, botany, taxonomy, cytogenetics, genetics, types of pollination and fertilization, mechanism, sterility and incompatibility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation, polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, quality improvement, molecular markers and marker assisted breeding, and QTLs, PPV and FR act of Gourds	2
2	Melons	2
3	Cucumber	2
4	Pumpkin	2
5	Squashes	1
6	Cauliflower	2
7	Cabbage	2
8	Kohlrabi	1
9	Broccoli	2
10	Brussels sprouts	1
11	Carrot	2
12	Radish	2
13	Turnip	1
14	Beet root	1
15	Onion	2
16	Sweet potato	2
17	Tapioca	1
18	Taro and yam	1
19	Beet leaf	1
20	Spinach	1
21	Amaranth	1
22	Coriander	1

Practical

Floral mechanisms favouring cross pollination. Development of inbred lines. Selection of desirable plants from breeding population. Observations and analysis of various quantitative

and qualitative traits in germplasm, hybrids and segregating generations. Induction of flowering, palynological studies, selfing and crossing techniques. Hybrid seed production of vegetable crops in bulk; Screening techniques for biotic and abiotic stress resistance in above mentioned crops. Demonstration of sib-mating and mixed population. Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques. Visit to breeding blocks

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Floral mechanisms favouring cross pollination	2
2	Development of inbred lines	1
3	Selection of desirable plants from breeding population	2
4	Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations	2
5	Induction of flowering, palynological studies, selfing and crossing techniques	2
6	Hybrid seed production of vegetable crops in bulk; Screening techniques for biotic and abiotic stress resistance in above mentioned crops	2
7	Demonstration of sib-mating and mixed population	2
8	Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques	2
9	Visit to breeding blocks	1
Total		**16**

Suggested Readings:

1. *Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons.*
2. *Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.*
3. *Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa publ. house.*
4. *Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: breeding and seed production. Vol. I. Kalyani.*
5. *Gardner, E.J., 1975, Principles of genetics. John Wiley and Sons.*
6. *Hayes, H.K., Immer, F.R. and Smith, D.C., 1955, Methods of plant breeding. McGraw-Hill.*
7. *Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.), 1993, Plant breeding-principles and prospects. Chapman and Hall.*
8. *Hazra, P. and Som M.G., 2015, Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p*
9. *Hazra, P. and Som, M.G., 2016, Vegetable seed production and hybrid technology(Second revised edition), Kalyani Publishers, Ludhiana, 459 p*
10. *Kalloo, G., 1988, Vegetable breeding. Vols. I-III. CRC Press.*
11. *Kalloo, G., 1998, Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.*

12. *Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro botanical publ.*
13. *Paroda, R.S. and Kalloo, G. (Eds.), 1995, Vegetable research with special reference to hybrid technology in Asia-Pacific region. FAO.*
14. *Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables.revised, ICAR.*
15. *Peter, K.V. and Hazra, P. (Eds), 2012,Hand book of vegetables.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p*
16. *Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables Volume II and III.Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.*
17. *Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency.*
18. *Prohens, J. and Nuez, F. 2007. Handbook of Plant Breeding- Vegetables (Vol I and II), Springer, USA.*
19. *Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ.*
20. *Simmonds, N.W., 1978, Principles of crop improvement. Longman.*
21. *Singh, B.D., 1983, Plant breeding. Kalyani Publ.*
22. *Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International book distributing Co.*
23. *Swarup, V., 1976, Breeding procedure for cross-pollinated vegetable crops. ICAR.*

VSC-531 SEED PRODUCTION OF VEGETABLE CROPS 3 (2+1)

Theory

Introduction, history, definition of seed and its quality, seed morphology, development and maturation, Apomixis and fertilization, Modes of propagation and reproductive behaviour, Pollination mechanisms and sex forms in vegetables, History of vegetable seed production, Status and share of vegetable seeds in seed industry.

Agro-climate and its influence on quality seed production, Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production, Methods of seed production, hybrid seeds and techniques of largescale hybrid seed production, Seed village concept.

Seed multiplication ratios and replacement rates in vegetables, Generation system of seed multiplication; Maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds, Seed quality and mechanisms of genetic purity testing.

Maturity standards, Seed harvesting, curing and extraction, Seed processing *viz*., cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing, Principles of seed storage,Orthodox and recalcitrant seeds, Seed dormancy.

Improved agro-techniques and field and seed standards- Improved agrotechniques;Field and seed standards in important solanaceous, leguminous and cucurbitaceous vegetables, cole crops, leafy vegetables, bulbous and root crops and okra;clonal propagation and multiplication in vegetative propagated crops; Seed plot technique and true potato seed production in potato.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Introduction of vegetable seed production, Definition of seed and its quality	2

2	Seed morphology, development and maturation; Apomixis and fertilization;	2
3	Modes of propagation and reproductive behaviour; Pollination mechanisms and sex forms in vegetables	2
4	History of vegetable seed production; Status and share of vegetable seeds in seed industry	2
5	Agro-climate and methods of seed production- Agro-climate and its influence on quality seed production	1
6	Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production	2
7	Methods of seed production, hybrid seeds and techniques of large scale hybrid seed production, Seed village concept	2
8	Seed multiplication and its quality maintenance- Seed multiplication ratios and replacement rates in vegetables.	2
9	Generation system of seed multiplication, Maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds	2
10	Seed quality and mechanisms of genetic purity testing	1
11	Seed harvesting, extraction and its processing- Maturity standards	2
12	Seed harvesting, curing and extraction; Seed processing viz., cleaning, drying and treatment of seeds	2
13	Seed health and quality enhancement, packaging and marketing	1
14	Principles of seed storage; Orthodox and recalcitrant seeds	1
15	Seed dormancy	1
16	Improved agro-techniques and field, Seed standards- Improved agrotechniques	1
17	Field and seed standards in important solanaceous, leguminous and cucurbitaceous vegetables	2
18	Cole crops, leafy vegetables, bulbous and root crops and okra;	2
19	Clonal propagation and multiplication in vegetative propagated crops	1
20	Seed plot technique and true potato seed production in potato	1
Total		**32**

Practical

Study of floral biology and pollination mechanisms in vegetables. Determination of modes of pollination. Field and seed standards. Use of pollination control mechanisms in hybrid seed production of important vegetables. Maturity standards and seed extraction methods. Seed sampling and testing. Visit to commercial seed production areas. Visit to seed processing plant. Visit to seed testing laboratories

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures

1	Study of floral biology and pollination mechanisms in vegetables	2
2	Determination of modes of pollination	2
3	Field and seed standards	1
4	Use of pollination control mechanisms in hybrid seed production of important vegetables	2
5	Maturity standards and seed extraction methods	2
6	Seed sampling and testing	2
7	Visit to commercial seed production areas	2
8	Visit to seed processing plant	2
9	Visit to seed testing laboratories	1
Total		**16**

Suggested Readings:

1. *Agarwaal, P. K. and Anuradha, V., 2018, Fundamentals of seed science and technology. Brilliant publications, New Delhi.*
2. *Agrawal, P.K. and Dadlani M. (Eds.), 1992, Techniques in seed science and technology. South asian Publ.*
3. *Agrawal, R.L. (Ed.), 1997, Seed technology. Oxford and IBH.*
4. *Basra, A.S., 2000, Hybrid seed production in vegetables. CRC press, Florida, USA.*
5. *Bench, A.L.R. and Sanchez, R.A., 2004, Handbook of seed physiology. Food products press, NY/ London.*
6. *Bendell, P.E. (Eds.), 1998, Seed science and technology: Indian forestry species. Allied Publ.*
7. *Chakraborty, S.K., Prakash, S., Sharma, S.P. and Dadlani, M., 2002, Testing of distinctiveness,uniformity and stability for plant variety protection. IARI, New Delhi*
8. *Copland, L.O. and McDonald, M.B., 2004, Seed science and technology, Kluwer Academic Press.*
9. *Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: breeding and seed production. Vol. I. Kalyani Publ.*
10. *George, R.A. T., 1999, Vegetable seed production (2nd Edition). CAB International.*
11. *Hazra, P. and Som, H.G. 2015, Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.*
12. *Kalloo, G., Jain, S.K., Vari, A.K. and Srivastava, U., 2006, Seed: A global perspective. Associated publishing company, New Delhi.*
13. *Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro botanical publ.*
14. *More, T.A., Kale, P.B. and Khule, B.W., 1996, Vegetable seed production technology. Maharashtra state seed corp.*
15. *Rajan, S. and Markose, B. L., 2007, Propagation of horticultural crops. New India publ. agency.*
16. *Singh, N.P., Singh, D.K., Singh, Y.K. and Kumar, V., 2006, Vegetable seed production technology. International book distributing Co.*
17. *Singh, S.P., 2001, Seed production of commercial vegetables. Agrotech publ. academy.*
18. *Singhal, N.C., 2003, Hybrid seed production. Kalyani publishers, New Delhi*
19.

VSC- 611 RECENT TRENDS IN VEGETABLE PRODUCTION 3(3+0)

Theory

Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost playhouses; net house production; crop modelling, organic gardening; vegetable production for pigments, export and processing ofSolanaceous crops: Tomato, brinjal, chili, sweet pepper and potato, Cole crops: Cabbage, cauliflower and knol-khol, sprouting broccoli, Okra, onion, peas and beans, amaranth and drumstick, Root crops and cucurbits: Carrot, beet root, turnip and radish and cucurbits, Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost playhouses; net house production; crop modelling, organic gardening; vegetable production for pigments, export and processing of Tomato	2
2	Brinjal	2
3	Chili	2
4	Sweet pepper	2
5	Potato	2

6	Cabbage	2
7	Cauliflower	2
8	Knol-khol	2
9	Sprouting broccoli	2
11	Okra	2
12	Onion	2
13	Peas and beans	2
14	Amaranth	2
15	Drumstick	2
16	Carrot	2
17	Beet root	2
18	Turnip	2
19	Radish	2
20	Cucurbits	2
21	Tuber crops: Sweet potato	2
22	Cassava	2
23	Elephant foot yam	2
24	Dioscorea and taro	2
Total		**48**

VSC-612ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS 3 (2+1)

Theory

Abiotic stress management in vegetable crops. Environmental stress - its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress. Mechanism and measurements - tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.Soil-plant-water relations - under different stress conditions in vegetable crops production and their management practices.Techniques of vegetable growing under water deficit, water logging, salinity and sodicity. Use of chemicals - techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Environmental stress - its types, soil parameters including pH,	3
2	Classification of vegetable crops based on susceptibility and	2
3	Tolerance to various types of stress	2
4	Mechanism and measurements - tolerance to drought,	2
5	Water logging	2
6	Soil salinity	2
7	Frost	2
8	Heat stress in vegetable crops	2
9	Soil-plant-water relations - under different stress conditions in	2

	vegetable crops production	
10	Soil-plant-water relations - under different stress conditions in vegetable crops production and their management practices	2
11	Techniques of vegetable growing under water deficit	1
12	Water logging	2
13	Salinity	2
14	Sodicity	2
15	Use of chemicals - techniques of vegetable growing under high and low temperature conditions	2
17	Use of chemicals and antitranspirants in alleviation of different stresses.	2
Total		**32**

Practical

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops. Measurement of tolerance to various stresses in vegetable crops. Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions. Use of chemicals for alleviation of different stresses.

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops	4
2	Measurement of tolerance to various stresses in vegetable crops	4
3	Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions	4
4	Use of chemicals for alleviation of different stresses.	4
Total		**16**

VSC- 621 ADVANCES IN BREEDING OF VEGETABLE CROPS3(3 +0)

Theory

Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, bio-fortification, in – vitrobreeding, marker assisted breeding, haploidy, development of transgenic of Solanaceous crops - Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato, Cucurbits and Cole crops, Legumes and leafy vegetables - Peas and Beans, Amaranth, Palak, Chenopods and Lettuce, Root crops and onion - Carrot, Beetroot, Radish, Turnip, Onion, Tuber crops - Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures

1	Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, bio-fortification, *in–vitro*breeding, marker assisted breeding, haploidy, development of transgenic of **Tomato**	2
2	Brinjal	2
3	Hot Peeper	2
4	Sweet Pepper	2
5	Okra	2
6	Potato	2
7	Cucurbits	2
8	Cole crops	2
9	Peas	2
10	Beans	2
11	Amaranth	2
12	Palak	2
13	Chenopods	2
14	Lettuce	2
15	Carrot	2
16	Beetroot	2
17	Radish	2
18	Turnip	2
19	Onion	2
20	Sweet potato	2
21	Tapioca	2
22	Elephant foot yam	2
23	Colocasia	2
24	Dioscorea	2
Total		**48**

VSC-622 SEED CRTIFICATION, PROCESSING AND STORAGE OF VEGETABLE SEEDS 3(2+1)

Theory

Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programs. Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes. Methods of seed drying and cleaning, seed

processing plant- layout and design, seed treatment, seed quality enhancement, packaging and marketing. Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post-harvest factors). Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation and marketing of seeds.

Lecture Schedule-Theory

S.No.	Topics	No. of Lectures
1	Seed certification and history,	1
2	Concepts and objectives	1
3	Seed certification agency	1
4	Phases of seed certification	1
5	Indian Minimum seed Certification standards,	1
6	Planning and management of seed certification programmes.	1
7	Principles and procedures of field inspection,	1
8	Seed sampling	1
9	Testing and granting certification,	1
10	OECD certification Schemes.	1
11	Principles of seed processing,	2
12	Methods of seed drying and cleaning	1
13	Seed processing plant- Layout and design	1
14	Seed treatment	2
15	Seed quality enhancement	1
16	Packaging and marketing.	1
17	Principles of Seed Storage	2
18	Orthodox/ recalcitrant seeds,	1
19	Types of storage (open, bulk, controlled, germplasm, cryopreservation)	1
20	Factors affecting seed longevity in storage (Pre and post-harvest factors)	1
21	Seed aging and deterioration	1
22	Seed aging and deterioration, maintenance of seed viability	2
23	Vigor during storage	1
24	Storage methods	1
25	Storage structures	2
26	Transportation and marketing of seeds	2
Total		**32**

Practical

General procedures of seed certification, Field inspection and standards, Isolation and rouging, Inspection and sampling at harvesting, threshing and processing. Testing physical purity, germination and moisture, grow-out test. Visit to regulatory seed testing and plant quarantine laboratories. Seed processing plants and commercial seed stores .

Lecture Schedule-Practical

S.No.	Topics	No. of Lectures
1	General procedures of seed certification	3
2	Field inspection and standards	2
3	Isolation and rouging	2
4	Inspection and sampling at harvesting, threshing and processing	2
5	Testing physical purity, germination and moisture, grow-out test	2
6	Visit to regulatory seed testing and plant quarantine laboratories	2
7	Seed processing plants and commercial seed stores	3
Total		**16**

Common Courses:

Thefollowingcourses(onecrediteach)willbeofferedtoallstudentsundergoingMaster'sdegreeprogramme:

1. LibraryandInformationServices
2. TechnicalWritingandCommunicationsSkills
3. IntellectualPropertyanditsmanagementinAgriculture
4. BasicConceptsinLaboratoryTechniques
5. AgriculturalResearch,ResearchEthicsandRuralDevelopment

Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The studentsmaybeallowedtoregisterthesecourses/similarcoursesontheseaspects,ifavailableonlineonSWAYAMoranyotherplatform.Ifastudenthasalreadycompletedanyofthesecoursesduring UG,he/shemaybepermittedtoregisterfor other related courses with the prior approval of the Head of Department (HoD)/BoardofStudies(BoS).

PGS-511 LIBRARYANDINFORMATIONSERVICES 1 (0+1)

Objectives

Toequipthelibraryuserswithskillstotraceinformationfromlibrariesefficiently,toapprisethemofinformationandknowledgeresources,tocarryoutliteraturesurvey, to formulate information search strategies, and to use modern tools (Internet,OPAC,searchengines,etc.)ofinformationsearch.

Practical

Introduction to library and its services; Role of libraries in education, research andtechnologytransfer;Classificationsystemsandorganizationoflibrary;Sourcesofinformation-PrimarySources,SecondarySourcesandTertiarySources;IntricaciesofabstractingandindeXingservices(ScienceCitationIndeX,BiologicalAbstracts,ChemicalAbstracts,CABIAbstracts,etc.);Tracinginformationfromreferencesources;Literaturesurvey;Citationtechniques/Preparationofbibliography;UseofCD-ROMDatabases,OnlinePublicAccessCatalogueandothercomputerizedlibraryservices;UseofInternetincludingsearchenginesanditsresources;e-resourcesaccessmethods.

PGS-531 Technical WritingAndCommunicationSkills 1(0+1)

Objectives

To equip the students/ scholars with skills to write dissertations, research papers,etc. To equip the students/ scholars with skills to communicate and articulate inEnglish(verbalaswellaswriting).

Practical

- Various forms of scientific writings- theses, technical papers, reviews, manuals,etc.;
- Variouspartsofthesisandresearchcommunications(titlepage,authorshipcontentspage,preface,introduction,reviewofliterature,materialandmethods,eXperimentalresultsanddiscussion);
- Writingofabstracts,summaries,précis,citations,etc.;
- Commonly usedabbreviationsinthethesesandresearchcommunications;
- Illustrations,photographsanddrawingswithsuitablecaptions;pagination,numberingoftablesandillustrations;
- Writingofnumbersanddatesinscientificwrite-ups;
- Editingandproof-reading;
- Writingofareviewarticle;
- CommunicationSkills-Grammar(Tenses,partsofspeech,clauses,punctuationmarks);
- Erroranalysis(Commonerrors),Concord,Collocation,Phoneticsymbolsandtranscription;
- Accentualpattern:Weakformsinconnectedspeech;
- Participationingroupdiscussion;
- Facinganinterview;
- Presentationofscientificpapers.

SuggestedReadings

1. *BarnesandNoble.RobertC.(Ed.).2005.SpokenEnglish:FlourishYourLanguage.*
2. *ChicagoManualofStyle.14thEd.1996.PrenticeHallofIndia.*
3. *Collins'CobuildEnglishDictionary.1995.*
4. *Harper Collins. Gordon HMand Walter JA. 1970.TechnicalWriting.3rdEd.*
5. *Holt,RinehartandWinston.HornbyAS.2000.Comp.OxfordAdvancedLearner'sDictionaryofCurrentEnglish.6thEd.OxfordUniversityPress.*
6. *JamesHS.1994. HandbookforTechnicalWriting.NTCBusinessBooks.*
7. *JosephG.2000.MLAHandbookforWritersofResearchPapers.5thEd.AffiliatedEast-WestPress.*
8. *MohanK.2005.SpeakingEnglishEffectively.MacMillanIndia.*
9. *RichardWS.1969.TechnicalWriting.*
10. *SethiJandDhamijaPV.2004.CourseinPhoneticsandSpokenEnglish.2ndEd.PrenticeHallofIndia.*
11. WrenPCandMartinH.2006.HighSchoolEnglishGrammarandComposition.S.Chand& Co.

PGS-532 INTELLECTUAL POPERTYANDITSMANAGEMENTIN AGRICULTURE 1(1+0)

Objectives

Themainobjectiveofthiscourseistoequipstudentsandstakeholderswithknowledge of Intellectual Property Rights (IPR) related protection systems, theirsignificance and use of IPR as a tool for wealth and value creation in a knowledge-basedeconomy.

Theory

HistoricalperspectivesandneedfortheintroductionofIntellectualPropertyRightregime;TRIPsandvariousprovisionsinTRIPSAgreement;IntellectualPropertyandIntellectualPropertyRights(IPR),benefitsofsecuringIPRs;IndianLegislationsfortheprotectionofvarioustypesofIntellectualProperties; Fundamentalsofpatents,copyrights,geographicalindications,designsandlayout,tradesecretsandtraditionalknowledge,trademarks,protectionofplantvarietiesandfarmers'rightsand biodiversity protection; Protectable subject matters, protection in biotechnology,protectionofotherbiologicalmaterials,ownershipandperiodofprotection;NationalBiodiversity protection initiatives; Convention on Biological Diversity; InternationalTreatyonPlantGeneticResourcesforFoodandAgriculture;Licensingoftechnologies, Materialtransferagreements,ResearchcollaborationAgreement,LicenseAgreement.

SuggestedReadings

1. *ErbischFHandMarediaK.1998.IntellectualPropertyRightsinAgricultural Biotechnology.CABI.*
2. *GanguliP.2001.IntellectualPropertyRights:UnleashingKnowledge Economy.McGraw-Hill.*
3. *IntellectualPropertyRights:KeytoNewWealthGeneration.2001.NRDC andAestheticTechnologies.*
4. *MinistryofAgriculture,GovernmentofIndia.2004.StateofIndianFarmer. Vol.V.TechnologyGenerationandIPRIssues.AcademicFoundation.*
5. *RothschildMandScottN.(Ed.).2003.IntellectualPropertyRightsin AnimalBreedingandGenetics.CABI.*
6. *SahaR.(Ed.).2006.IntellectualPropertyRightsinNAMandOther DevelopingCountries:ACompendiumonLawandPolicies.DayaPubl. House.The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; TrademarksAct,1999;TheCopyrightAct,1957andamendments;Layout DesignAct,2000;PPVandFRAct2001,andRules2003;TheBiological DiversityAct,2002.*

PGS-533 BASICCONCEPTSINLABORATORYTECHNIQUES 1 (0+1)

Objectives

Toacquaintthestudentsaboutthebasicsofcommonlyusedtechniquesinlaboratory.

Practical

- SafetymeasureswhileinLab;
- Handlingofchemicalsubstances;
- Useofburettes,pipettes,measuringcylinders,flasks,separatoryfunnel,
  - condensers,micropipettesandvaccupets;
- Washing,dryingandsterilizationofglassware;
- Dryingofsolvents/chemicals;
- Weighingandpreparationofsolutionsofdifferentstrengthsandtheir

- dilution;
- Handlingtechniquesofsolutions;
- Preparationofdifferentagro-chemicaldosesinfieldandpotapplications;
- Preparationofsolutionsofacids;
- Neutralisationofacidandbases;
- Preparationofbuffersofdifferentstrengthsandp Hvalues;
- Useandhandlingofmicroscope,laminarflow,vacuumpumps,viscometer,
  - thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath,
  - oilbath;
  - Electricwiringandearthing;
  - Preparationofmediaandmethodsofsterilization;
  - Seedviabilitytesting,testingofpollenviability;
  - Tissueculture ofcropplants;
  - Descriptionoffloweringplantsinbotanicaltermsinrelationtotaxonomy.

SuggestedReadings

1. *FurrAK.2000.CRCHandBookofLaboratorySafety.CRCPress.*
2. *GabbMHandLatchemWE.1968.AHandbookofLaboratorySolutions.ChemicalPubl.Co.*

PGS-534 AGRICULTURAL RESEARCH,RESEARCHETHICSANDRURALDEVELOPMENT PROGRAMMES 1 (1+0)

Objectives

To enlighten the students about the organization and functioning of agriculturalresearch systems at national and international levels, research ethics, and ruraldevelopmentprogrammesandpoliciesofGovernment.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need,scope, opportunities; Role in promoting food security, reducing poverty and protectingthe environment; National Agricultural Research Systems (NARS) and RegionalAgriculturalResearchInstitutions;ConsultativeGrouponInternationalAgriculturalResearch(CGIAR):InternationalAgriculturalResearchCentres(IARC),partnershipwithNARS, roleasapartnerintheglobalagriculturalresearchsystem,strengthening capacities at national and regional levels; International fellowshipsforscientificmobility.

UNIT II Research ethics: research integrity, research safety in laboratories, welfareof animals used in research, computer ethics, standards and problems in researchethics.

UNIT III Concept and connotations of rural development, rural development policiesandstrategies.Ruraldevelopmentprogrammes:CommunityDevelopmentProgramme,IntensiveAgriculturalDistrictProgramme,Specialgroup–AreaSpecificProgramme,IntegratedRuralDevelopmentProgramme(IRDP)PanchayatiRajInstitutions,Co-operatives,VoluntaryAgencies/Non-GovernmentalOrganisations.Criticalevaluationofruraldevelopmentpoliciesandprogrammes.Constraintsinimplementationofruralpoliciesandprogrammes.

SuggestedReadings

1. *BhallaGSandSinghG.2001.IndianAgriculture-FourDecadesofDevelopment.SagePubl.*
2. *PuniaMS.ManualonInternationalResearchandResearchEthics.CCSHaryanaAgriculturalUniversity,Hisar.*
3. *RaoBSV.2007.RuralDevelopmentStrategiesandRoleofInstitutions-Issues,InnovationsandInitiatives.MittalPubl.*
4. *SinghK.1998.RuralDevelopment-Principles,PoliciesandManagement.SagePubl.*

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