Course Curriculum

(As per V Deans' Committee's Recommendations)

B.Sc. (Agriculture)

Degree Programme

University of Agricultural Sciences
GKVK, Bengaluru-560 065

2018

University of Agricultural Sciences, Bengaluru

B.Sc. (Agriculture)

CONTENTS

(i)

* Non-gradial courses

Note: 1. PED. 111 (0+1) Spread over for one year

2. NSS. 111 (0+1) Spread over for two years

(ii)

1	2	3	4	5
2	FSN. 321	Food Processing, Food Safety Standards and Value Addition	1+1	44
		Total	**3+1=4**	

FORESTRY AND ENVIRONMENTAL SCIENCE

1	FES. 111	Introduction to Forestry	1+1	45
2	FES. 221	Environmental Studies and Disaster Management	2+0	46
		Total	**3+1=4**	

GENETICS AND PLANT BREEDING

1	GPB. 121	Fundamentals of Cytogenetics	1+1	48
2	GPB. 211	Fundamentals of Genetics	1+1	49
3	GPB. 221	Fundamentals of Plant Breeding	2+1	49
4	GPB. 311	Crop Breeding	1+1	50
5	GPB. 321	Intellectual Property Rights	1+0	51
		Total	**6+4=10**	

HORTICULTURE

1	HRT. 121	Fundamentals of Horticulture and Fruit Crops Production	1+1	51
2	HRT. 211	Production Technology of Vegetable Crops	1+1	52
3	HRT. 221	Production Technology of Flower Crops and Landscaping	1+1	53
4	HRT. 311	Production Technology of Plantation Crops, Spices, Medicinal and Aromatic Plants	1+1	53

1	2	3	4	5
5	HRT. 321	Post Harvest Management and Value Addition of Fruits and Vegetables	1+1	53
		Total	**5+5=10**	

PLANT BIOTECHNOLOGY

1	PBT. 121	Fundamentals of Plant Biotechnology	2+1	54
		Total	**2+1=3**	

PLANT PATHOLOGY

1	PAT. 211	Fundamentals of Plant Pathology	2+1	55
2	PAT. 221	Principles of Plant Disease Management	1+1	56
3	PAT. 311	Diseases of Field Crops and their Management	2+1	58
4	PAT. 321	Diseases of Horticultural Crops and their Management	1+1	58
		Total	**6+4=10**	

SEED SCIENCE & TECHNOLOGY

1	SST. 311	Principles and Practices of Seed Production	1+1	59
2	SST. 321	Post Harvest Seed Technology and Quality Assurance	1+1	60
		Total	**2+2=4**	

SERICULTURE

1	SER. 321	Introduction to Sericulture	1 +1	62
		Total	**1+1=2**	

* To be offered by faculty of respective Department from CoA, GKVK

1	2	3	4	5
		SOIL SCIENCE & AGRICULTURAL CHEMISTRY		
1	SAC. 121	Fundamentals of Soil Science	2+1	63
2	SAC. 211	Soil Chemistry	1+1	63
3	SAC. 311	Problematic Soils and their Management, Geoinformatics	1+1	64
4	SAC. 321	Manures, Fertilizers and Soil Fertility Management	2+1	65
		Total	**10=6+4**	

ABSTRACT

Basic Sciences and Humanities	5+4	
Agricultural and Allied Subjects	71+56	
Student **"READY"** Programme		66
• RAWE- Rural Agricultural Work Experience	0+20	68
• EL/HoT- Experiential Learning/Hands on Training	0+20	69
Non Gradial Courses:		
• Physical Education	0+1	
• NSS	0+1	
• Kannada	0+2	
• Educational Tour	0+1	85
• Remedial Courses	2(1+1) / (2+0)	
Grand Total	**(9+127+20+20+7*)=183**	

* Non--gradial Courses

BASIC SCIENCES AND HUMANITIES

BCM. 111 Plant Biochemistry 1+1

Theory: Biochemistry-Introduction and importance, Plant cell-Structure and organellar functions. Biomolecules–Structure, properties and reactions: amino acids, peptides and proteins, lipids, carbohydrates, nucleotides and nucleic acids. Enzymes- Factors affecting the activities, classifications, immobilization and other industrial applications. Metabolism – Basic concepts. glycolysis, citric acid cycle, pentose phosphate pathway, β-oxidation of fatty acids, electron transport and oxidative phosphorylation. General reactions of amino acids degradation. Metabolic regulation. Secondary metabolites- terpenoids, alkaloids, phenolics.

Practical: Protein denaturation- heat, pH, precipitation of proteins with heavy metals, Estimation of crude protein, Estimation of protein by Lowry method, Enzymes assays; Extraction of nucleic acids; Extraction of oil from oil seeds; Estimation of crude fat, Estimation of iodine number and saponification value of an oil, Quantitative and qualitative determination of sugars, Paper chromatography for the separation of sugars, Determination of phenols, chlorophyll and ascorbic acid.

CSC. 111 Computer Science and Agri-informatics 1+1

Theory: Introduction to Computers, organization and architecture of Computers, Memory Concepts, Units of Memory, Operating System, definition and UNIX, WINDOWS.

Basic Computer networks, Internet and World Wide Web (WWW), Editing and Formatting a document, Database, concepts and types, creating database. Introduction to Computer C-Programming language, concepts and standard input/output operations. Introduction to ICT and uses in agriculture. Introduction to Computer-controlled devices (automated systems) for Agri-input management, Smartphone

apps in Agriculture. Introduction to Bioinformatics and Omics database NCBI, searching and accessing genome sequences and protein sequences. Introduction to GIS and its applications in Agriculture. Introduction to MIS and Decision Support System and its applications in Agriculture.

Practical: Introduction of different operating systems such as DOS and WINDOWS. Creating Files & Folders. Introduction of programming languages. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific Document. MS-EXCEL - Creating a spreadsheet, use of statistical tools, writing expressions, creating graphs, analysis of scientific data. MS-ACCESS: Creating Database, preparing queries and reports, demonstration of Agri-information system. Introduction to World Wide Web (WWW). Demonstration of HTML page design of e-Agriculture. Omics database of NCBI searching and accessing genome sequences and protein sequences, alignment of two genome sequences and alignment of two protein sequences.

ENG. 111 Comprehension and Communication Skills in English 1+1

Theory: Reading Comprehension, Vocabulary- Antonym, Synonym, Homophones, Homonyms, often confused words. Exercises to help the students in the enrichment of vocabulary based on TOEFL and other competitive examinations. Functional grammar: Articles, Prepositions, Verb, Subject verb Agreement, Transformation, Synthesis, Direct and Indirect Narration. Writing Skills: Paragraph writing, Précis writing, Report writing, Proposal writing and Letter Writing. Interview Skills. Resume/CV Preparation and Job applications. Synopsis Writing.

Practical: Listening Comprehension: Listening to short talks, lectures, speeches (scientific, commercial and general in nature). Oral Communication: Phonetics, stress and intonation, Conversation practice. Presentation skills and Public speaking. Reading skills:

Reading and comprehension of general and technical articles, precise writing, summarizing, abstracting; Group discussion.

AST. 221 Agricultural Statistics 2+1

Theory: Introduction to Statistics and its Applications in Agriculture, Classification & Frequency Distributions of data, Diagrammatic Representation of Data: Bar & Pie diagrams, Graphical Representations of Data: Histogram, Frequency Polygon, Frequency curve and Cumulative frequency curve (Ogives).Measures of Central Tendency: Concepts & Definition, Characteristics of ideal Average, Arithmetic Mean, Median, Mode, Quartiles, Deciles & Percentiles (both for Ungrouped and Grouped data), Geometric Mean and Harmonic Mean (Ungrouped data).Measures of Dispersion: Concepts & Definition, Types of Measures of Dispersion: Range, Quartile deviation, Absolute Mean Deviation from mean and median, Standard Deviation and Variance, and Co-efficient of dispersion (both for Ungrouped and Grouped data). Moments, Measures of Skewness and Kurtosis (both for Ungrouped and Grouped data).Concept of Set Theory: , Permutation & Combinations. Theory: of Probability: Concept & Definition, Addition and Multiplication rules (without proof). Theoretical Probability distributions: Binomial, Poisson and Normal Distribution, their Properties & Applications.

Simple Correlation Analysis: Definition, Measures of Correlation: Scatter diagram, Karl Pearson product moment and Spearman's rank correlation coefficients and their properties. Simple Linear Regression Analysis: Definition, Fitting of simple linear regression equations Y on X and X on Y, Properties of regression coefficient, interrelation between correlation and regression.

Introduction to Sampling Theory: , Sampling versus Complete Enumeration, Methods of Sampling, Type of Sampling- Simple Random Sampling (with and without replacement), Use of Random Number Tables for selection of Simple Random Sample, Concept of Sampling distribution and standard error, concept of systematic,

stratified and cluster sampling along with their advantage & disadvantages .

Test of Significance: Introduction, Null & Alternative hypothesis, Types of Errors, Level of significance, degrees of freedom, Critical & Acceptance regions. Large sample tests: Z-Test for Means - One and Two sample Means for Known and Unknown population variance. Small sample test: Student t-test for Means - One and Two sample means, Paired t-test and F-test for two population variances. Chi-Square test: Test for Goodness of Fit, Test for independence of attributes for *rXc* contingency table, 2x2 contingency table with Yates correction, and test for single population variance.

Introduction to Analysis of Variance and its Assumptions, Analysis of Variance for One & Two Way Classification. Concept of design of experiments: Basic Principle of Experimental Design: Randomization, Replication & Local control, Basic Designs: CRD, RCBD and LSD, their advantages and disadvantages.

Practical: Construction of Frequency Distribution tables. Diagrammatic presentation of data: Bar diagrams & pie diagrams. Graphical Representation of Data: Histogram, Frequency polygon, Frequency curve and Cumulative frequency curve (Ogives). Computation of Measures of Central Tendency: Arithmetic Mean, Median, Mode, Quartiles, Deciles & Percentiles (both for Ungrouped and Grouped data), Geometric Mean and Harmonic Mean (Ungrouped data). Computation of Measures of Dispersion: Range, Quartile deviation, Absolute Mean Deviation, Standard Deviation and Variance and Co-efficient of dispersion (both for Ungrouped and Grouped data). Computation of Moments, Measures of Skewness and Kurtosis (both for Ungrouped and Grouped data), Problems on permutation and combination. Problems on Simple Probability, Addition and Multiplication rules. Computation of probabilities using Binomial, Poisson and Normal Distributions. Computation of Correlation Coefficient: Karl Pearson product moment and Spearman's rank correlation coefficients. Fitting of Simple linear

Regression Equations Y on X, & X on Y. Use of Random Number Tables for selection of Simple Random Sample. Problems on Large sample tests: Z-Test for Means - One and Two sample means for known and unknown population variance. Problems on Small sample tests: Student t-test for Means - One and Two sample means, Paired t-test, and F-test two population variances. Problems on Chi-Square test: Test for Goodness of Fit, Test for independence of attributes for *rXc* contingency table, 2x2 contingency table with Yates correction and test for single population variance. Problems on Analysis of Variance for One & Two Way Classified data. Problems on CRD, RCBD and LSD.

PED. 111 Physical Education and Yoga Practices 0+1

PART I

1. Teaching of skills of Football – demonstration, practice of the skills, correction, involvement in game situation (For girls teaching of Badminton)
2. Teaching of different skills of Football – demonstration, practice of the skills, correction, involvement in game situation (For girls teaching of Badminton)
3. Teaching of advance skills of Football – involvement of all the skills in game situation with teaching of rules of the game
4. Teaching of skills of Basketball – demonstration, practice of the skills, correction of skills, involvement in game situation
5. Teaching of skills of Basketball – demonstration, practice of the skills, involvement in game situation
6. Teaching of skills of Basketball – involvement of all the skills in game situation with teaching of rule of the game
7. Teaching of skills of Kabaddi – demonstration, practice of the skills, correction of skills, involvement in game situation
8. Teaching of skills of Kabaddi – demonstration, practice of the skills, correction of skills, involvement in game situation

9. Teaching of advance skills of Kabaddi – involvement of all the skills in game situation with teaching of rule of the game
10. Teaching of skills of Ball Badminton – demonstration, practice of the skills, correction of skills, involvement in game situation
11. Teaching of skills of Ball Badminton – involvement of all the skills in game situation with teaching of rule of the game
12. Teaching of some of Asanas – demonstration, practice, correction and practice
13. Teaching of some more of Asanas – demonstration, practice, correction and practice
14. Teaching of skills of Table Tennis – demonstration, practice of skills, correction and practice and involvement in game situation
15. Teaching of skills of Table Tennis – demonstration, practice of skills, correction and practice and involvement in game situation
16. Teaching of skills of Table Tennis – involvement of all the skills in game situation with teaching of rule of the game
17. Teaching – Meaning, Scope and importance of Physical Education
18. Teaching – Definition, Type of Tournaments
19. Teaching – Physical Fitness and Health Education
20. Construction and laying out of the track and field (*The girls will have Badminton and Volleyball).

PART II

1. Teaching of skills of Hockey – demonstration practice of the skills and correction.
2. Teaching of skills of Hockey – demonstration practice of the skills and correction. And involvement of skills in games situation

3. Teaching of advance skills of Hockey – demonstration practice of the skills and correction. Involvement of all the skills in games situation with teaching of rules of the game
4. Teaching of skills of Kho-Kho – demonstration practice of the skills and correction.
5. Teaching of skills of Kho-Kho – demonstration practice of the skills and correction. Involvement of the skills in games situation
6. Teaching of advance skills of Kho-Kho – demonstration practice of the skills and correction. Involvement of all the skills in games situation with teaching of rules of the game
7. Teaching of different track events – demonstration practice of the skills and correction.
8. Teaching of different track events – demonstration practice of the skills and correction.
9. Teaching of different track events – demonstration practice of the skills and correction with competition among them.
10. Teaching of different field events – demonstration practice of the skills and correction.
11. Teaching of different field events – demonstration practice of the skills and correction.
12. Teaching of different field events – demonstration practice of the skills and correction.
13. Teaching of different field events – demonstration practice of the skills and correction with competition among them.
14. Teaching of different asanas – demonstration practice and correction.
15. Teaching of different asanas – demonstration practice and correction.
16. Teaching of different asanas – demonstration practice and correction.

17. Teaching of different asanas – demonstration practice and correction.
18. Teaching of weight training – demonstration practice and correction.
19. Teaching of circuit training – demonstration practice and correction.
20. Teaching of calisthenics – demonstration practice and correction.

Note: 1) Compulsory Uniform: Half pants, Tee Shirts, Shoes and socks all white (Girls will have white Tee Shirt and Track pants)

2) The games mentioned in the practical may be inter changed depending on the season and facilities.

NSS. 111 National Service Scheme 0+1

PART I

Introduction and basic components of NSS:Orientation: history, objectives, principles, symbol, badge; regular programes under NSS, organizational structure of NSS, code of conduct for NSS volunteers, points to be considered by NSS volunteers awareness about health.

NSS programmes and activities: Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analysing guiding financial patterns of scheme, youth programme/ schemes of GOI, coordination with different agencies and maintenance of diary.

Understanding youth: Definition, profile, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.

Community mobilization: Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership.

Social harmony and national integration: Indian history and culture, role of youth in nation building, conflict resolution and peace-building

Volunteerism and shramdan: Indian tradition of volunteerism, its need, importance, motivation and constraints; shramdan as part of volunteerism

Citizenship, constitution, human rights, human values and ethics: Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information, human values and ethics.

Family and society: Concept of family, community (PRIs and other community based organisations) and society

PART II

Importance and role of youth leadership: Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership

Life competencies: Definition and importance of life competencies, problem-solving and decision-making, inter personal communication

Youth development programmes: Development of youth programmes and policy at the national level, state level and voluntary sector; youth-focused and youth-led organstions

Health, hygiene and sanitation: Definition needs and scope of health education; role of food, nutrition, safe drinking water, water born diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programmes and reproductive health.

Youth health, lifestyle, HIV AIDS and first aid: Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid

Youth and yoga: History, philosophy, concept, myths and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

PART III

Vocational skill development: To enhance the employment potential and to set up small business enterprises skills of volunteers, a list of 12 to 15 vocational skills will be drawn up based on the local conditions and opportunities. Each volunteer will have the option to select two skill-areas out of this list

Issues related environment: Environmental conservation, enrichment and sustainability, climatic change, natural resource management (rain water harvesting, energy conservation, forestation, waste land development and soil conservations) and waste management

Disaster management: Introduction and classification of disaster, rehabilitation and management after disaster; role of NSS volunteers in disaster management.

Entrepreneurship development: Definition, meaning and quality of entrepreneur; steps in opening of an enterprise and role of financial and support service institution.

Formulation of production oriented project: Planning, implementation, management and impact assessment of project

Documentation and data reporting: Collection and analysis of data, documentation and dissemination of project reports

PART IV

Youth and crime: Sociological and psychological factors influencing youth crime, cyber crime, pear mentoring in preventing crime and awareness for juvenile justice

Civil/self defence: Civil defence services, aims and objectives of civil defence; needs and training of self defence

Resource mobilization: Writing a project proposal of self fund units (SFUs) and its establishment

Additional life skills: Positive thinking, self-confidence and esteem, setting life goals and working to achieve them, management of stress including time management.

ಕನ್ನಡ ಪಠ್ಯಕ್ರಮ

ಕನ್ನಡ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ

KAN. 111 **0+1**

ಅ. ಕಾವ್ಯ–ಕಥೆ

ಜನಪದ ಗೀತೆಗಳು–ಜನಪದರು; ಶರಣರ ವಚನಗಳು–ಜೇಡರದಾಸಿಮಯ್ಯ, ಬಸವಣ್ಣ, ಆಯ್ದಕ್ಕಿ ಲಕ್ಕಮ್ಮ; ಹೊಸ ಬಾಳಿನ ಗೀತೆ– ಕುವೆಂಪು; ತಿಳಿದವರೇ ಹೇಳಿ–ವೈದೇಹಿ; ಜೀತ– ಡಾ॥ ಬೆಸಗರಹಳ್ಳಿ ರಾಮಣ್ಣ; ಒಂದು ಖಾಸಗಿ ಪತ್ರ–ವಿನಯಾ ಒಕ್ಕುಂದ.

ಆ. ಕೃಷಿ ಬರಹ

ಆಧುನಿಕ ಪೂರ್ವ ಕನ್ನಡ ಕೃಷಿ ಸಾಹಿತ್ಯ ಪರಿಚಯ – ಡಾ॥ಜಿ.ವೀರಭದ್ರಗೌಡ, ಕನ್ನಡದಲ್ಲಿ ಕೃಷಿವಿಜ್ಞಾನ ಸಾಹಿತ್ಯದ ಉಗಮ ಮತ್ತು ವಿಕಾಸ–ಡಾ॥ ಜೆ. ಬಾಲಕೃಷ್ಣ, ಎಲ್ ಫಾರ್ ಲೈನ್ ಅಲ್ಲ: ಲಕ್ಷ್ಮಣಯ್ಯ – ಡಾ॥ ಟಿ.ಎಸ್.ಚನ್ನೇಶ್, ಅಹಾರವೆಂಬ ಆಯುಧ–ನಾಗೇಶ ಹೆಗಡೆ

ಇ. ಪ್ರಾಯೋಗಿಕ

ಅನುವಾದ, ಪಾರಿಭಾಷಿಕ ಪದರಚನೆಯ ವಿಧಾನಗಳು.

ಕನ್ನಡೇತರ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ/ For Non Kannada Speaking Students

KAN. 112 **0+1**

Development of listening and speaking skills with Kannada structure pattern - Introducing each other - Conversation between friends - Enquiring about family - Plan to go for a movie - Routine activities of a student - In a book shop - Introducing College/University - Conversation between a farmer and a Scientist - Data collection in a village – Conversation on going on a tour.

Development of writing and reading skills with Kannada structure pattern - Kannada Script practice and reading.

ಕನ್ನಡ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ

KAN. 121 **0+1**

ಅ. ಕಾವ್ಯ – ಕಥೆ– ಜನಪದ – ಸಂಸ್ಕೃತಿ ಮತ್ತು ಕನ್ನಡ ಪ್ರಜ್ಞೆ –ಸಂಕೀರ್ಣ

ಬೇವಿನಹಟ್ಟಿ ಕಾಳಮ್ಮನ ಸಾಲು– ಜನಪದ, ಗೋವಿನ ಹಾಡು– ಜನಪದ, ಕರ್ನಾಟಕ ಜಾನಪದ ಲೋಕದೃಷ್ಟಿ – ಪುರುಷೋತ್ತಮ ಬಿಳಿಮಲೆ, ಕೆರೆಗೆ ಹಾರ– ಜನಪದ, ನೀರೆಂಬ ಜೀವ ದ್ರವ – ಜೆ.ಬಾಲಕೃಷ್ಣ, ಸೂಫಿ ಕತೆಗಳು, ಕನ್ನಡದ ಶುದ್ಧತೆ – ಕೆ.ವಿ.ನಾರಾಯಣ, ವಚನಕಾರರು ಮತ್ತು ಭಾಷೆ, ಕದಂಬರ ಕನ್ನಡ ಲಿಪಿ – ಷ.ಶೆಟ್ಟರ್, ಅವನತಿ – ಪೂರ್ಣಚಂದ್ರ ತೇಜಸ್ವಿ, ಇಲ್ಲಿ ಯಾರೂ ಮುಖ್ಯರಲ್ಲ, ಯಾರೂ ಅಮುಖ್ಯರಲ್ಲ... – ಕೃಪಾಕರ ಸೇನಾನಿ, ಕೃಷಿ ಗಾದೆಗಳು – ಜನಪದ, ಕೃಷಿ ಗಾದೆಗಳ ಅವಲೋಕನ – ಜಿ. ವೀರಭದ್ರಗೌಡ.

ಈ. ಪ್ರಾಯೋಗಿಕ

ಕನ್ನಡದಲ್ಲಿ ಕೃಷಿ ಸಾಹಿತ್ಯ ಪ್ರಕಾರಗಳು ಮತ್ತು ಅವುಗಳ ರಚನಾ ಸ್ವರೂಪ; ವ್ಯವಹಾರ ಕನ್ನಡ–ಪತ್ರಲೇಖ.

ಕನ್ನಡೇತರ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ/ For Non Kannada Speaking Students

KAN. 122 **0+1**

Development of listening and speaking skills with Kannada structure pattern - Conversation between a Doctor and a Patient; About Children's Education; Halebid-Belur; Discussing about Examination and Future Plan.

Development of writing and reading skills with Kannada structure pattern : Translation of simple sentences English into Kannada, Selected lesson for reading (Nada Geete, Kannada Habbagalu, Prekshaniya Sthalagalu, Kannada Kavi, Kannada Vignani).

AGRICULTURAL AND ALLIED SUBJECTS

AGRONOMY

AGR. 111 Fundamentals of Agronomy 2+1

Theory: Agronomy and its scope, Agriculture as an art, science and business of crop production, Factors affecting crop production,

History of agriculture development in India and Karnataka, Importance and scope of agriculture, classification of crops, Seeds and sowing, Soil and its components, properties, fertility and productivity and their management, Tillage and tilth, Crop density and geometry, Crop nutrition - manures and fertilizers, nutrient use efficiency, Growth and development of crops, ideotypes, Cropping systems and its principles, Crop adaptation and distribution, crop management technologies in problematic areas, Harvesting and threshing of crops. Weeds- importance, classification, crop weed competition, concepts of weed management-principles and methods, herbicides- classification, selectivity and resistance, allelopathy.

Practicals: Identification of crops, seeds and fertilizers, Classification of field crops, tillage implements, Study and practice of different methods of ploughing, Study of different methods of sowing, Study of seed drills, intercultural implements, Study of fertilizers, manures and green manures, Calculation of fertilizers and seed rates, Study on seed germination and plant population, Preparation of FYM and compost, Participation in ongoing field operations, Study of agro-climatic zones of Karnataka and India. Study and identification of dry land and waste land weeds. Study and identification of garden land, wet land and aquatic weeds. Calculation of herbicide doses and their spray.

AGR. 121 Water Management 1+1

Theory: Definition of irrigation, water resources; soil water relations; Basic terms in water management and irrigation. Study of soil moisture constantans and hydrodynamic relation. Measurement of soil moisture-direct and indirect methods; Expression of soil moisture and their mutual relations, Plant water relationship –critical stages. Meaning and impact of water stress, water availability and its relationship with nutrientavailability and losses. Water management of crops – its definition, meaning, measurement and relevance in crop production, concept of evapotranspiration and its management, factors affecting water management, study of water requirement of

field and horticultural crops, methods of irrigation – surface, subsurface, sprinkler and drip, constraints and advantages of different methods. Efficiency of irrigation and methods to measure them, Quantitative estimation of irrigation water – direct and indirect methods, Expression of flowing water and mutual relations, Concept of water use efficiency and methods to improve water use efficiency, Assessment of irrigation requirement, Scheduling of irrigation – Approaches and methods, Suitability of water for irrigation, Concept of drainage and methods.

Practical: Soil moisture determination by direct and indirect methods, Study and installation of tensiometer and soil moisture gauges,Determination of maximum water holding capacity, field capacity, permanent wilting point and bulk density, Determination of infiltration rate and capillarity in soil, Study of methods of flow measurement, use of weirs, orifices, Parshall flume and water meters, Surface & sub-surface irrigation methods, Micro irrigation methods, Water requirement of different crops, On-farm irrigation structures, Drainage structures, Practice of numerical examples.

AGR. 122 Introductory Agrometeorology & Climate Change 1+1

Theory: Meaning and scope of agricultural meteorology; Earth atmosphere- its composition, extent and structure; Atmospheric weather variables; Atmospheric pressure, its variation with height; Wind, types of wind, daily and seasonal variation of wind speed, cyclone, anticyclone, land breeze and sea breeze; Nature and properties of solar radiation, solar constant, depletion of solar radiation, short wave, longwave and thermal radiation, net radiation, albedo; Atmospheric temperature, temperature inversion, lapse rate, daily and seasonal variations of temperature, vertical profile of temperature, Energy balance of earth; Atmospheric humidity, concept of saturation, vapor pressure, process of condensation, formation of dew, fog, mist, frost, cloud; Precipitation, process of precipitation, types of precipitation such as rain, snow, sleet, and hail, cloud

formation and classification; Artificial rainmaking. Monsoon-mechanism and importance in Indian agriculture, Weather hazards - drought, floods, frost, tropical cyclones and extreme weather conditions such as heat-wave and cold-wave. Agriculture and weather relations; Modifications of crop microclimate, climatic normals for crop and livestock production. Weather forecasting- types of weather forecast and their uses. Climate change, climatic variability, global warming, causes of climate change and its impact on regional and national Agriculture and mitigation strategies

Practical: Visit of Agrometeorological Observatory, site selection of observatory, exposure of instruments and weather data recording. Measurement of total, shortwave and longwave radiation, and its estimation using Planck's intensity law. Measurement of albedo and sunshine duration, computation of Radiation Intensity using BSS. Measurement of maximum and minimum air temperatures, its tabulation, trend and variation analysis. Measurement of soil temperature and computation of soil heat flux. Determination of vapor pressure and relative humidity. Determination of dew point temperature. Measurement of atmospheric pressure and analysis of atmospheric conditions. Measurement of wind speed and wind direction, preparation of windrose. Measurement, tabulation and analysis of rain. Measurement of open pan evaporation and evapotranspiration. Computation of PET and AET.

AGR. 211 Crop Production Technology-I 2+1

Theory: Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield of Kharifcrops. Cereals – rice, maize, wheat, sorghum, pearl millet and finger millet, Nutrimillets/small millets: kodo millet, foxtail maillet, Proso millet, little millet, baranyard millet Pulses- chickpea, peas,pigeonpea, mungbean, urdbean, cowpea, horsegramand lentil; Forage crops: sorghum, cowpea, cluster bean,napier, berseem, lucerne and oat.

Practical: Study of area, production and productivity of cereals, pulses and forage crops in Karnataka, India and world, Raising of important cereals, pulses and forage crops in the crop museum, Rice nursery preparation, transplanting of Rice, effect of seed size on germination and seedling vigour crops, effect of sowing depth on germination of crops, identification of weeds in crops, top dressing and foliar feeding of nutrients, study of yield contributing characters and yield calculation of crops, study of crop varieties and important agronomic experiments at experimental farm. study of forage experiments, morphological description of crops, visit to research centres of related crops.Green leaf manuring and use of bio-fertilizers in rice, Fertilizer management in cereals, pulses and forage crops, fertilizer management of paddy, preservation of fodder and silage making,

AGR. 212 Practical Crop Production-II (Irrigated) 0+1

Practicals: Crop planning, raising field crops in an area of 5 guntas by each student. Field preparation, seed, treatment, nursery raising, sowing, nutrient, water and weed management and management of insect-pests diseases of crops, harvesting, threshing, drying winnowing, storage and marketing of produce. The emphasis will be given to seed production, mechanization, resource conservation and integrated nutrient, insect-pest and disease management technologies. Preparation of balance sheet including cost of cultivation, net returns per student.

AGR. 221 Crop Production Technology-II 1+1

Theory: Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield of oilseed crops- groundnut, sunflower, rapeseed and mustard, soybean, sesamum, niger, safflower, castor,linseed, Commercial crops – sugarcane, cotton, jute, mesta.

Practicals: Study of area, production and productivity of oilseeds and commercial crops in Karnataka, India and world, Raising of important oilseed and commercial crops in the crop museum, Planting methods of sugarcane, Study on methods of shelling and rhizobium and PSB seed treatment in groundnut, study on nipping in castor and safflower, Methods of testing the maturity of sugarcane and computation of commercial cane sugar, Study of yield contributing characters of oilseed and commercial crops, Study on quality parameters of cotton, study of bast fibre like mesta, jute and their retting, visit to research stations of related crops/sugar factory.

AGR. 311 Practical Crop Production-I (Rainfed) 0+1

Practicals: Crop planning, raising field crops in an area of 5 guntas by each student. Field preparation, seed, treatment, nursery raising, sowing, nutrient, water and weed management and management of insect-pests diseases of crops, harvesting, threshing, drying winnowing, storage and marketing of produce. The emphasis will be given to seed production, mechanization, resource conservation and integrated nutrient, insect-pest and disease management technologies. Preparation of balance sheet including cost of cultivation, net returns per student.

AGR. 312 Experimental Techniques in Agricultural Research 0+1

Practicals: Aims and objectives of field experiments, Essence, levels and methods of research, Identification and statement of problem, selection of treatments, selection of site, plot shape and size, Use of random sampling numbers in field experiments, Layout of field experiments and conduct of field trials by individual student, Recording of observations from field experiments, Review collection and writing of reference cards, Basic concepts and measurement of data, Analysis of variance and test of significance, Experimental designs and basic principles of experimental design, Completely Randomized Design (CRD), Randomized Complete Block design

(RCBD), Latin Square design (LSD), Factorial Concept, each student has to conduct a micro plot field experiment. Study of tabulation, analysis of experimental data and experimental results, Transformation of data and Preparation of research report & presentation of results

AGR. 321 Farming Systems, Organic Farming and Precision Agriculture 2+1

Theory: Farming System-scope, importance and concept, Types and systems of farming system and factors affecting types of farming, Farming system components and their maintenance, Cropping system and pattern, multiple cropping system, Efficient cropping system and their evaluation, Allied enterprises and their importance, Tools for determining production and efficiencies in cropping and farming system; Sustainable agriculture-problems and its impact on agriculture, indicators of sustainability, adaptation and mitigation, conservation agriculture strategies in agriculture, HEIA, LEIA and LEISA and its techniques for sustainability, Integrated farming system-historical background, objectives and characteristics, components of IFS and its advantages, Site specific development of IFS model for different agro-climatic zones, resource use efficiency and optimization techniques, Resource cycling and flow of energy in different farming system, farming system and environment, Organic farming, principles and its scope in India; Initiatives taken by Government (central/state), NGOs and other organizations for promotion of organic agriculture; Organic ecosystem and their concepts; Organic nutrient resources and its fortification; Restrictions to nutrient use in organic farming; Choice of crops and varieties in organic farming; Fundamentals of insect, pest, disease and weed management under organic mode of production; Operational structure of NPOP; Certification process and standards of organic farming; Processing, leveling, economic considerations and viability, marketing and export potential of organic products. Precision agriculture: concepts and techniques; their issues and concerns for

Indian agriculture. Global Positioning System (GPS) Geographic Information System (GIS). Site Specific Nutrient Management (SSNM) for nutrient and irrigation management practices. Comparative yield, quality and farm profits under SSM practices v/s Variable Rate Technology (VRT) practices.

Practical: Visit of organic farms and outlets to study the various components and their utilization. Visit to IFS model in different agro-climatic zones of nearby states University/ institutes and farmers field to study the various components and their utilization; Preparation of enrich compost, vermicompost, bio-fertilizers/bio-inoculants and their quality analysis; Indigenous technology knowledge (ITK) for nutrient, insect, pest disease and weed management; Cost of organic production system; Post harvest management; Quality aspect, grading, packaging and handling.

AGR. 322 Rainfed Agriculture and Watershed Management 1+1

Theory: Rainfed agriculture: Introduction, types, History of rainfed agriculture and watershed in India; Problems and prospects of rainfed agriculture in India ; Soil and climatic conditions prevalent in rainfed areas; Soil and water conservation techniques, Drought: types, effect of water deficit on physio- morphological characteristics of the plants, Crop adaptation and mitigation to drought; Water harvesting: importance, its techniques, Efficient utilization of water through soil and crop management practices, Management of crops in rainfed areas, Contingent crop planning for aberrant weather conditions, Concept, objective, principles and components of watershed management, factors affecting watershed management.

Practical: Studies on climate classification, studies on rainfall pattern in rainfed areas of the country and pattern of onset and withdrawal of monsoons. Studies on cropping pattern of different rainfed areas in the country and demarcation of rainfed area on map of India. Interpretation of meteorological data and scheduling of supplemental

irrigation on the basis of evapo-transpiration demand of crops. Critical analysis of rainfall and possible drought period in the country, effective rainfall and its calculation. Studies on cultural practices for mitigating moisture stress. Characterization and delineation of model watershed. Field demonstration on soil & moisture conservation measures. Field demonstration on construction of water harvesting structures. Visit to rainfed research station/watershed.

AGRICULTURAL ECONOMICS

AEC. 111 Fundamentals of Agricultural Economics 2+0

Theory: *Economics:* Meaning, scope and subject matter, definitions, activities, approaches to economic analysis; micro and macro economics, positive and normative analysis. Nature of economic Theory: ; rationality assumption, concept of equilibrium, economic laws as generalization of human behavior. Basic concepts: Goods and services, desire, want, demand, utility, cost and price, wealth, capital, income and welfare. Agricultural economics: meaning, definition, characteristics of agriculture, importance and its role in economic development. ***Technical change and types,*** Agricultural planning and development in the country. ***Land reforms: meaning of land tenure, land tenancy, land reform measures – abolition of intermediaries, tenancy reforms, fixation of ceiling on land holdings, consolidation of holdings, development of cooperative farming. Agricultural labour and farm mechanization.*** Demand*:* meaning, law of demand, demand schedule and demand curve, determinants, utility Theory: ; law of diminishing marginal utility, equi-marginal utility principle. Consumer's equilibrium and derivation of demand curve, elasticity of demand: concept and measurement of price elasticity, income elasticity and cross elasticity. Supply: Stock v/s supply, law of supply, supply schedule, supply curve, determinants of supply, elasticity of supply. Production: process, creation of utility, factors of production, laws of returns and returns to scale. Market structure: meaning and types of market, basic features of perfectly competitive and imperfect markets.

Distribution Theory: meaning, factor market and pricing of factors of production. Concepts of rent, wage, interest and profit. *National income:* Meaning and importance, circular flow, concepts of national income accounting and approaches to measurement, difficulties in measurement. Population: Importance, Malthusian and Optimum population theories, natural and socio-economic determinants, current policies and programmes on population control. Money: Barter system of exchange and its problems, evolution, meaning and functions of money, classification of money, money supply, general price index, inflation and deflation. Banking: Role in modern economy, Agricultural and public finance: meaning, micro v/s macro finance, need for agricultural finance, public revenue and public expenditure. *Tax:* meaning, direct and indirect taxes, agricultural taxation, VAT. Economic systems*:* Concepts of economy and its functions, important features of capitalistic, socialistic and mixed economies, elements of economic planning, *NITI Ayoga.*

AEC. 121 Agricultural Finance & Co-operation 1+1

Theory: Agricultural Finance - meaning, scope and significance, credit needs and its role in Indian agriculture. Agricultural credit: meaning, definition, need, classification. Credit analysis: 3 R'S and 5 C'S of credits ***Loan repayment plans***. Sources of agricultural finance: institutional and non-institutional sources, ***types of banks, functions of commercial and central bank, credit creation policy,*** social control and nationalization of commercial banks, micro financing including KCC and SHGs. Lead bank scheme, RRBs, Scale of finance and unit cost. Introduction to higher financing institutions – RBI, NABARD, ADB, IMF, World Bank, Insurance and Credit Guarantee Corporation of India. Cost of credit. Recent development in agricultural credit-***Banking reforms and their implication on agricultural credit – Narasimham Committee and other reports.*** Preparation and analysis of financial statements – Balance Sheet and Income Statement. Basic guidelines for preparation of project reports-

Time value of money, capital budgeting techniques – PBP, ARR, NPV, BCR, IRR, Bank norms – SWOT analysis.

Agricultural Cooperation – Meaning, brief history of cooperative development in India, objectives, principles of cooperation, significance of cooperatives in Indian agriculture. Agricultural Cooperation in India - credit, multi-purpose cooperatives, farmers' service cooperative societies, role of ICA, NCUI, NCDC,

Practical: Determination of most profitable level of capital use. Optimum allocation of ***scarce***capital among different enterprises. ***Exercise on Time value of money, capital budgeting techniques – PBP, ARR, NPV, BCR, IRR,***Analysis of performance of cooperatives using ***secondary***data. Analysis of performance of commercial banks and RRB's using ***secondary*** data. Visit to cooperative banks, credit societies, commercial banks, ***NABARD, lead bank*** to acquire firsthand knowledge of their management, schemes and procedures. Estimation of credit requirement of farm business – ***Case studies.*** Preparation and analysis of balance sheet – ***case studies.*** Preparation and analysis of income statement – ***case studies***. Appraisal of a loan proposal – ***case studies.*** Techno-economic parameters for preparation of projects. Preparation of bankable projects for various agricultural ***crops*** / products ***including their*** value added products.

AEC. 311 Agricultural Marketing, Trade and Prices 2+1

Theory: Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets**; *studying the problems of marketing-Functional, institutional, commodity and behavioural approaches, Market forces – Demand and Supply, Consumer surplus and producer surplus,***nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; product life cycle (PLC) and competitive strategies:

Meaning and stages in PLC; characteristics of PLC; strategies in different stages of PLC; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; ***Price determination under different types of markets,***market promotion – advertising, personal selling, sales promotion and publicity – their meaning and merits & demerits; marketing process and functions: Marketing process-concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labeling (AGMARK); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing ***and market regulation, Market research- information and intelligence,*** Public sector institutions- CWC, SWC, FCI, CACP & DMI – their objectives and functions; cooperative marketing in India, ***NAFED***Risk in marketing: Types of risk in marketing; speculation & hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; need for agricultural price policy***; Administered Prices, CACP, MSP, MIS***, Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; GATT and WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR.

Quality control, HACCP, Eco-mark, Agri-export zones, Export-import bank of India.

Practical: Plotting and study of demand and supply curves and calculation of elasticities**;** Study of relationship between market

arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to local markets to study various marketing functions performed by different agencies, identification of marketing channels for ***commodities,*** collection ***and analysis*** of data on marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions – NAFED, SWC, CWC***, e-marketing***, ***regulated market,*** cooperative marketing society, Export house, etc. to study their organization and functioning; Application of principles of comparative advantage of international trade.

AEC. 321 Farm Management, Production and Resource Economics 1+1

Theory: Meaning and concept of farm management, objectives and relationship with other sciences. Meaning and definition of farms, its types and characteristics, factor determining types and size of farms. Principles of farm management: ***Differences between farm management and production economics,***concept of production function and its type - ***Linear, quadratic, Cobb Douglas models, meaning and interpretation.***Uses of production function in decision-making, ***Laws of returns: Law of variable proportions (factor-product),***factor-factor and product-product relationships, law of equi-marginal returns, principle of opportunity cost, law of comparative advantage. Meaning and concept of cost, types of costs and their interrelationship, ***fixed costs, sunken costs, valuation and depreciation of farm assets***, total and average cost curves in the short and long run and farm management cost concepts (CACP), Concept and estimation- gross farm income, net farm income, family labor income and farm business income. Farm business analysis: meaning and concept of farm income and profitability, technical and economic efficiency measures in crop and livestock enterprises. ***Discounted Cash Flow Measures and their role in financial evaluation, equipping farmer as decision maker – production,***

strategic decisions etc.,Importance of farm records and accounts in managing a farm, various types of farm records needed to maintain on farm, ***single entry and double entry book keeping***, farm inventory, balance sheet, profit and loss accounts. Meaning and importance of farm planning and budgeting, partial and complete budgeting, steps in farm planning and budgeting, linear programming, appraisal of farm resources, selection of crops and livestock's enterprises. Concept of risk and uncertainty***in farming***, nature and sources of risks and its management strategies**,** Crop/livestock/ machinery insurance ***schemes*** – weather based crop insurance, features, determinants of compensation, PMFBY.

Concepts of resource economics, ***Significance of NRE in farming,*** differences between NRE and agricultural economics, ***unique properties of natural resources - land, surface water, groundwater, environment, biodiversity, ecosystem services: uniqueness, indispensability, irreversibility, invisibility, remoteness, intricacy, synergy, ambiguous property rights, externalities, market failure, free riding, property rights.***Positive and negative externalities in agriculture, inefficiency and welfare loss, internalization of externalities, important issues in economics and management of common property resources of land, water, ***pasture, fishery and*** forest resources etc.

Practical: Preparation of farm layout. Determination of cost of fencing of a farm. Computation of depreciation cost of farm assets. ***Illustration of loss minimization principle,*** Application of equi-marginal returns/opportunity cost principle in allocation of farm resources. Determination of most profitable level of inputs use in a farm production process. Determination of least cost combination of inputs. Selection of most profitable enterprise combination. ***Formulation of LP problems.*** Application of cost principles including CACP concepts in the estimation of cost of crop and livestock enterprises. Preparation of farm plan and budget, ***partial budgeting exercises, Exercise on book keeping in farm,***

Amortization, Illustration of costing of groundwater irrigation. Visit to IFS farms, farm section office, cooperative farms, and other representative farms.

AGRICULTURAL ENGINEERING

AEG. 111 Introductory Soil and Water Conservation Engineering 1+1

Theory: Introduction to Soil and Water Conservation, causes of soil erosion. Definition and agents of soil erosion, water erosion: Forms of water erosion. Gully classification and control measures. Soil loss estimation by universal Loss Soil Equation. Soil loss measurement techniques. Principles of erosion control: Introduction to contouring, strip cropping. Contour bund. Graded bund and bench terracing. Grassed water ways and their design. Water harvesting and its techniques. Wind erosion: mechanics of wind erosion, types of soil movement. Principles of wind erosion control and its control measures.

Practical: General status of soil conservation in India. Calculation of erosion index. Estimation of soil loss. Measurement of soil loss. Preparation of contour maps. Design of grassed water ways. Design of contour bunds. Design of graded bunds. Design of bench terracing system. Problem on wind erosion.

AEG. 211 Farm Machinery and Power 1+1

Theory: Status of Farm Power in India, Sources of Farm Power, I.C. engines, working principles of I C engines, comparison of two stroke and four stroke cycle engines, Study of different components of I.C. engine, I.C. engine terminology and solved problems, Familiarization with different systems of I.C. engines: Air cleaning, cooling, lubrication, fuel supply and hydraulic control system of a tractor, Familiarization with Power transmission system : clutch, gear box, differential and final drive of a tractor, Tractor types, Cost analysis of tractor power and attached implement, Familiarization

with Primary and Secondary Tillage implement, Implement for hill agriculture, implement for intercultural operations, Familiarization with sowing and planting equipment, calibration of a seed drill and solved examples, Familiarization with Plant Protection equipment, Familiarization with harvesting and threshing equipment.

Practical: Study of different components of I.C. engine. To study air cleaning and cooling system of engine, Familiarization with clutch, transmission, differential and final drive of a tractor, Familiarization with lubrication and fuel supply system of engine, Familiarization with brake, steering, hydraulic control system of engine, Learning of tractor driving, Familiarization with operation of power tiller, Implements for hill agriculture, Familiarization with different types of primary and secondary tillage implements: mould plough, disc plough and disc harrow . Familiarization with seed-cum-fertilizer drills their seed metering mechanism and calibration, planters and transplanter Familiarization with different types of sprayers and dusters Familiarization with different inter-cultivation equipment, Familiarization with harvesting and threshing machinery.

AEG. 221 Renewable Energy and Green Technology 1+1

Theory: Classification of energy sources, contribution of these of sources in agricultural sector, Familiarization with biomass utilization for biofuel production and their application, Familiarization with types of biogas plants and gasifiers, biogas, bioalcohol, biodiesel and biooil production and their utilization as bioenergy resource, introduction of solar energy, collection and their application, Familiarization with solar energy gadgets: solar cooker, solar water heater, application of solar energy: solar drying, solar pond, solar distillation, solar photovoltaic system and their application, introduction of wind energy and their application.

Practical: Familiarization with renewable energy gadgets. To study biogas plants, To study gasifier, To study the production process of biodiesel, To study briquetting machine, To study the production

process of bio-fuels. Familiarization with different solar energy gadgets. To study solar photovoltaic system: solar light, solar pumping, solar fencing. To study solar cooker, To study solar drying system. To study solar distillation and solar pond.

AEG. 321 Protected Cultivation and Secondary Agriculture 1+1

Theory: Green house technology: Introduction, Types of Green Houses; Plant response to Green house environment, Planning and design of greenhouses, Design criteria of green house for cooling and heating purposes. Green house equipments, materials of construction for traditional and low cost green houses. Irrigation systems used in greenhouses, typical applications, passive solar green house, hot air green house heating systems, green house drying. Cost estimation and economic analysis.

Important Engineering properties such as physical, thermal and aero & hydrodynamic properties of cereals, pulses and oilseed, their application in PHT equipment design and operation. Drying and dehydration; moisture measurement, EMC, drying Theory: , various drying method, commercial grain dryer (deep bed dryer, flat bed dryer, tray dryer, fluidized bed dryer, recirculatory dryer and solar dryer). Material handling equipment; conveyer and elevators, their principle, working and selection.

Practical: Study of different type of green houses based on shape. Determine the rate of air exchange in an active summer winter cooling system. Determination of drying rate of agricultural products inside green house. Study of green house equipments. Visit to various Post Harvest Laboratories. Determination of Moisture content of various grains by oven drying & infrared moisture methods. Determination of engineering properties (shape and size, bulk density and porosity of biomaterials). Determination of Moisture content of various grains by moisture meter. Field visit to seed processing plant.

AGRICULTURAL ENTOMOLOGY

AET. 121 Fundamentals of Entomology 2+1

Theory: History of Entomology in India. Position of the insect in Animal kingdom. Factors for insect's abundance. Major points related to dominance of Insecta in Animal kingdom. Classification of phylum Arthropoda upto classes. Relationship of class Insecta with other classes of Arthropoda. Morphology: Structure and functions of insect cuticle and molting. Body segmentation. Structure of Head, thorax and abdomen. General external structure and modifications of insect antennae, mouth parts, legs, Wing venation, modifications and wing coupling apparatus. Structure of male and female genital organ. Metamorphosis and diapause in insects. Types of larvae and pupae. Structure and functions of digestive, circulatory, excretory, respiratory, nervous, secretary (Endocrine) and reproductive system, in insects. Types of reproduction ininsects. Major sensory organs like simple and compound eyes, chemoreceptors. Systematics: Taxonomy –importance, history and development and binomial nomenclature. Definitions of Biotype, Sub-species, Species, Genus, Family and Order. Classification of class Insecta upto Orders, basic groups of present day insects with special emphasis to orders and families of Agricultural importance like Orthoptera: Acrididae, Tettigonidae, Gryllidae, Gryllotalpidae; Dictyoptera: Mantidae, Blattidae; Odonata; Isoptera: Termitidae; Thysanoptera: Thripidae; Hemiptera: Pentatomidae, Coreidae, Cimicidae, Pyrrhocoridae, Lygaeidae, Miridae, Reduviidae, Cicadellidae, Delphacidae, Aphididae, Coccidae, Aleyrodidae, Lophophidae, Aleurodidae, Pseudococcidae; Neuroptera: Chrysopidae; Hemirobidae; Lepidoptera: Pieridae, Papiloinidae, Noctuidae, Nymphalidae, Sphingidae, Pyralidae, Gelechiidae, Arctiidae, Saturnidae, Bombycidae; Coleoptera: Coccinellidae, Chrysomelidae, Cerambycidae, Curculionidae, Bruchidae, Scarabaeidae; Hymenoptera: Tenthridinidae, Apidae. Trichogrammatidae, lchneumonidae, Braconidae, Chalcididae; Encyrtidae;Bethylidae,

Formicidae,Diptera: Cecidomyiidae, Tachinidae, Agromyziidae, Culicidae,Muscidae, Tephritidae, Tabanidae, Syrphidae.

Practical: Methods of collection and preservation of insects including immature stages; External features of Cockroach/Grasshopper/Blister beetle;study of close relatives of insects, phylum Arthropoda.Types of insect antennae, mouthparts and legs; Wing venation, types of wings and wing coupling apparatus. Types of insect larvae and pupae; Dissection of digestive system in insects (Grasshopper, Cockroach); Dissection of male and female reproductive systems in insects (Grasshopper, Cockroach); Study of characters of orders Orthoptera, Dictyoptera, Odonata, Isoptera, Thysanoptera, Hemiptera, Lepidoptera, Neuroptera, Coleoptera, Hymenoptera, Diptera and their families of agricultural importance.

Note: Students should submit 50 insect specimens representing different families and orders.

AET. 211 Insect Ecology, Principles of Pest Management and Natural Enemies 2+1

Theory: Insect Ecology: Introduction, Environment and its components. Effect of abiotic factors–temperature, moisture, humidity, rainfall, light, atmospheric pressure and air currents. Effect of biotic factors – food competition, natural and environmental resistance. Concepts of Balance of life in nature, biotic potential and environmental resistance and causes for outbreak of pests in agro-ecosystem.

Categories of insect pests, IPM: Introduction, history, importance, concepts, principles and tools of IPM. Economic importance of insect pests and pest risk analysis. Methods of detection and diagnosis of insect pest. Calculation and dynamics of economic injury level and importance of Economic threshold level. Methods of control: Host plant resistance, cultural, mechanical, physical, legislative, biological and chemical control. Ecological management of crop environment. Introduction to conventional pesticides for the insect pests

management. Survey surveillance and forecasting of Insect pest. Development and validation of IPM module. Implementation and impact of IPM (IPM module for Insect pest . Safety issues in pesticide uses. Political, social and legal implication of IPM. Case histories of important IPM programmes. Study of insecticides including mode of actions, formulations. Pest resurgence and insecticide resistance.

Insect orders bearing predators and parasitoids used in pest control and their mass multiplication techniques. Important species of pollinator, weed killers and scavengers with their importance.

Practical : Methods of diagnosis and detection of various insect pests, Methods of insect pests measurement, Assessment of crop yield losses, calculations based on economics of IPM, Identification of biocontrol agents, different predators and natural enemies. Mass multiplication of NPV, coccinella, green lace wing and other important bioagents. Identification and nature of damage of important insect pests and their management.Insecticides formulations, plant protections equipments, Crop (agro-ecosystem) dynamics of a selected insect pest. Plan & assess preventive strategies (IPM module) and decision making. crop monitoring attacked by insect, pest and diseases, Awareness campaign at farmers' fields. Identification of major parasitoids and predators commonly being used in biological control.

Note: Students should submit 25 insect specimens representing parasitoids, predator, weed killer and scavengers.

AET. 221 Insect Pests of Horticultural Crops and their Management 1+1

Theory: General account on nature and types of damage by different arthropod pests. Scientific name, order, family, host range, distribution, biology and bionomics, nature of damage, and management of major pests and control practices for other important arthropod pests of various vegetable crops, fruit crops, plantation crops, ornamental crops, narcotics, flowers, spices and condiments.

Pest of crops grown under protected cultivation. Pests of tuber crops, important vectors of plant diseases of horticultural crops.

Practical: Identification of different types of damage. Identification and study of life cycle and seasonal history of various insect pests attacking crops and their produce: (a) Vegetable Crops; (b) Fruit Crops; (c) Plantation, gardens, Narcotics, spices & condiments. Identification of insect pests. Identification of pests of protected cultivation crops.Determination of fruit and spices moisture content. Methods of sampling for pest damage assessment. Visit to nearby Horticultural research stations.

Note: Students should submit 50 insect specimens representing different Horticultural crops pests.

AET. 311 Insect Pests of Field Crops & Stored Grains and their Management 1+1

Theory: General account on nature and type of damage by different arthropods pests. Scientific name, order, family, host range, distribution, biology and bionomics, nature of damage, and management of major pests and scientific name, order, family, host range, distribution, nature of damage and control practice other important arthropod pests of various field crops, Factors affecting losses of stored grain and role of physical, biological, mechanical and chemical factors in deterioration of grain. Insect pests, mites, rodents, birds and microorganisms associated with stored grain and their management. Storage structure and methods of grain storage and fundamental principles of grain store management. Important vectors of plant diseases of field crops.

Practical: Identification of different types of damage. Identification and study of life cycle and seasonal history of various insect pests attacking crops and their produce: (a) Field Crops; Identification of insect pests and Mites associated with stored grain. Determination of insect infestation by different methods. Assessment of losses due to insects. Calculations on the doses of insecticides application

technique. Fumigation of grain store / godown. Identification of rodents and rodent control operations in godowns. Identification of birds and bird control operations in godowns. Determination of moisture content of grain. Methods of grain sampling under storage condition. Visit to nearest FCI godowns.

Note: Students should submit 50 insect specimens representing different crops and stored product insects.

AGRICULTURAL EXTENSION

AEX. 111 Rural Sociology, Education Psychology and Constitution of India 0+2

Practical: Sociology and Rural sociology: Definition and scope, its significance in agriculture extension, Social Ecology, Rural society, Social Groups, Social Stratification, Culture concept, Social Institution, Social Change & Development. Educational psychology: Meaning & its importance in agriculture extension. Behavior: Cognitive, affective, psychomotor domain, Personality, Learning, Motivation, Theories of Motivation, Intelligence.

Constitution of India: Meaning, Preamble and Characteristics of Constitution of India. Fundamental Rights and Duties. Directive Principles of State Policy. Constitutional provisions for welfare of SCs and STs, Minorities, Women and Children. Union Executive: President, Vice-President, Prime Minister, Council of Ministers – Powers and Functions. Parliament and Supreme Court of India – Powers and Functions. State Executive: Governor, Chief Minister, Council of Ministers. Legislature and Judiciary: Powers and Functions; Electoral Process; Human Rights Commission – Structure, Powers and Functions.

AEX. 121 Fundamentals of Agricultural Extension Education and Rural Development 1+1

Theory: Education: Meaning, definition & Types; Extension Education- meaning, definition, scope and process; objectives and

principles of Extension Education; Extension Programme planning-Meaning, Process, Principles and Steps in Programme Development. Extension systems in India: extension efforts in pre-independence era (Sriniketan, Marthandam, Firka Development Scheme, Gurgaon Experiment) and post-independence era (Etawah Pilot Project, Nilokheri Experiment); various extension/ agriculture development programmes launched by ICAR/ Govt. of India (IADP, IAAP, HYVP, KVK, IVLP, ORP, ND,NATP, NAIP). New trends in agriculture extension: privatization of extension, cyber extension/ e-extension, market-led extension, farmer-led extension, expert systems.

Rural Development: concept, meaning, definition; various rural development programmes launched by Govt. of India. Community Development-meaning, definition, concept & principles, Philosophy of C.D. Rural Leadership: concept and definition, types of leaders in rural context; extension administration: meaning and concept, principles and functions. Monitoring and evaluation: concept and definition, monitoring and evaluation of extension programmes; transfer of technology: concept and models, capacity building of extension personnel.

Practical: To get acquainted with university extension system. Group discussion- exercise; handling and use of audio visual equipments and digital camera and LCD projector; preparation and use of AV aids. Preparation of extension literature – leaflet, booklet, folder, pamphlet news stories and success stories. Presentation skills exercise; micro teaching exercise. A visit to village to understand the problems being encountered by the villagers/ farmers; to study organization and functioning of DRDA and other development departments at district level. Visit to NGO and learning from their experience in rural development. Understanding PRA techniques and their application in village development planning; exposure to mass media.

AEX. 211 Communication and Diffusion of Agricultural Innovations 1+1

Theory: Communication: meaning and definition; Principles and Functions of Communication. Models and barriers to communication. Agriculture journalism; diffusion and adoption of innovation: concept and meaning, process and stages of adoption. Extension teaching methods: meaning, classification, individual, group and mass contact methods, ICT Applications in TOT (New and Social Media), media mix strategies. Diffusion and Adoption of Innovations – Meaning, Definition, Models and adoption Process, Innovation – Decision Process – Elements, Adopter categories and their characteristics, Factors influencing adoption process; Capacity building of Extension Personnel and Farmers - Meaning, Definition, Types of training, Training of farmers, farm women and Rural youth – FTC and KVK.

Practical: Simulated exercises on communication; Identifying the Problems, Fixing the Priorities and selecting the most important problem for preparation of a project. Developing a project based on identified problem in a selected village. Organization of Group discussion and Method demonstration. Visit to KVK / FTC. Planning and Writing of scripts for Radio and Television. Audio Visual aids – Meaning, Importance and Classification. Visit to community radio and television studio for understanding the process of programme production. Planning & Preparation of visual aids - Charts, Posters, Over Head Projector (OHP) Transparencies, Power Point Slides. Planning and Preparation of Agricultural Information materials – Leaflet, Folder, Pamphlet, News Stories, Success Stories. Field diary and lab record; indexing, footnote and bibliographic procedures. Handling of Public Address Equipment (PAE) System, Still camera, Video Camera and Liquid Crystal Display (LCD) Projector. Development of schedules, Questionnaires and field visits for Data Collection.

AEX. 321 Entrepreneurship Development and Business Communication 1+1

Theory: Concept of Entrepreneur, Entrepreneurship Development, Characteristics of entrepreneurs; SWOT Analysis & achievement motivation, Government policy and programs and institutions for entrepreneurship development. Impact of economic reforms on Agribusiness/ Agrienterprises, Entrepreneurial Development Process; Business Leadership Skills; Developing organizational skill (controlling, supervising, problem solving, monitoring & evaluation), Developing Managerial skills, Business Leadership Skills (Communication, direction and motivation Skills), Problem solving skill. Supply chain management and Total quality management, Project Planning Formulation and report preparation. Financing of enterprise, Opportunities for agri-entrepreneurship and rural enterprise.

Practical: Assessing entrepreneurial traits, problem solving skills, managerial skills and achievement motivation, exercise in creativity, time audit through planning, monitoring and supervision, identification and selection of business idea, preparation of business plan and proposal writing. Visit to entrepreneurship development institute and entrepreneurs.

AGRICULTURAL MICROBIOLOGY

AMB. 111 Fundamentals of Microbiology 1+1

Theory: Origin and evolution of Microbial life. Brief history of microbiology. Microscopes and microscopy. Overview of cell structure of prokaryotes and eukaryotes. General properties of viruses, overview of plant, animal and bacterial viruses, viriods and prions. Different groups of Microorganisms- Bacteria, Fungi, Algae and Protozoa. Microbial nutrition and culture media. Overview of microbial metabolism: glycolysis, citric acid cycle, anaerobic respiration,

photosynthesis and fermentation. Microbial growth - measurement of growth, effect of environmental factors on growth. Qualitative and quantitative methods for the study of microorganisms. Microbial genetics: genetic recombination, conjugation, transformation, transduction, mutation and mutants, plasmids, transposons and insertion sequences, cloning vectors. Control of microbial growth: heat sterilization, radiation sterilization, filter sterilization, chemical growth control, disinfectants, antiseptics and antibiotics. Microbial ecology- Microorganisms in nature and their interaction, methods in microbial ecology, Microbial interactions with higher organisms – plants and animals. Concepts of Immunology - Cells and organs of immune system, antigen- antibody reactions, types of immunity, polyclonal and monoclonal antibodies.

Practical: Equipments used in a microbiology laboratory. Microscopy – principles and applications. Preparation of different culture media and sterilization methods. Isolation, pure culture and preservation of microorganisms. Staining techniques- simple, negative, capsule, endospore, Gram's staining etc. Qualitative and quantitative methods for the study of microorganisms. Influence of environmental factors on microorganisms. Biochemical activities of bacteria. Microscopic observation of bacteria, fungi, algae and protozoa.

AMB. 221 Soil and Applied Microbiology 1+1

Theory: Occurrence and distribution of microorganisms in nature. Soil as a habitat for microbes. Soil microorganisms - bacteria, fungi, algae, protozoa and viruses. Soil enzymes. Role of microorganisms in biogeochemical cycles of carbon, nitrogen, potassium, phosphorus, sulphur and secondary and tertiary nutrients. Soil biotechnology - utilization of microorganisms in improving soil productivity. Microbial interactions - neutralism, commensalism, synergism, mutualism, competition, amensalism, parasitism and predation. Plant microbe interactions and their biotechnological implications, rhizosphere microflora, symbiotic and free living nitrogen fixing

microorganisms, ectomycorrhizal and endomycorrhizal associations. Microbiology of hydrosphere and atmosphere. Microorganisms associated with animals and insects. Potentials and limitations of using microorganisms as agents of biological control of insect pests and diseases. Pesticide micro-flora interactions. Biodegradation, bioconversion of industrial, domestic and agricultural wastes. Industrial use of microorganisms - biochemical processes involved and biotechnological applications. Microbiology of milk and milk products. Single cell protein. Role of microorganisms in biochemical transformation of raw and processed foods. Food spoilage, food poisoning and food borne infections. Principles and methods of Food preservation.

Practical: Determination of enzyme activities in soil. Mineralization of carbon, nitrogen, phosphorus and sulphur. Plant microbe interactions: free living nitrogen fixers, legume - *Rhizobium* symbiosis, mycorrhizal symbiosis, microbial inoculants, Azolla - *Anabena* symbiosis, *Casurina* - *Frankia* symbiosis, Study of epiphytic microorganisms. Study of beneficial microorganisms in Agriculture - Biofertilizer preparation, Compost making, Biogas production etc. Cultivation of mushrooms. Microbiological examination of water and effluents. Microorganisms in bread and wine making. Microflora associated with vertebrates and invertebrates. Microbiological examination of raw processed foods. Microbiological examination of milk and milk products.

ANIMAL SCIENCE

ASC. 311 Livestock, Poultry & Fish Production Management 2+1

Theory: Role of livestock in the national economy. Reproduction in farm animals and poultry. Housing principles, space requirements for different species of livestock and poultry. Management of calves, growing heifers and milch animals. Management of sheep, goat and swine. Incubation, hatching and brooding. Broiler production. Management of growers and layers. Important Indian and exotic

breeds of cattle, buffalo, sheep, goat, swine and poultry. Improvement of farm animals and poultry. Importance of Indigenours Live stock and poultry species. Feeding principles of livestock and poultry. Feed ingredients. Feed supplements and additives for livestock and poultry ration. Study of livestock and poultry diseases. Prevention, vaccination schedule and control of important diseases of livestock and poultry. Marketing and Economics of livestock and poultry. Fisheries resources of india. Importance of Inland fisheries. important fishes and their production. New vistas in Inland fish production.

Practical: External body parts of cattle, buffalo, sheep, goat, swine and poultry. Handling and restraining of livestock. Identification methods of farm animals and poultry. Visit to IDF and IPF to study breeds of livestock and poultry and daily routine farm operations and farm records. Judging of cattle, buffalo and poultry. Culling of livestock and poultry. Planning and layout of housing for different types of livestock and poultry. Computation of rations for livestock. Clean milk production, milking methods. Hatchery operations, incubation and hatching equipments. Management of chicks, growers and layers. De-beaking, dusting and vaccination. Economics of cattle, buffalo, sheep, goat, swine and poultry production. Visit to inland fisheries unit.

APICULTURE

API. 311 Introduction to Apiculture 1+1

Theory: : Importance of Bees and Beekeeping, History and Development of Beekeeping; Species of honeybees and their colony structure; Morphology of honeybees; Anatomy of honeybees – Digestive, reproductive, nervous, Circulatory and Glandular system; Colony organization; Bee biology; Caste determination in honeybees; Age related activities of workers; Nest architecture; Behaviors in honeybees- Foraging, Communication, Robbing, Swarming and Homeostatis; How, when and where to start beekeeping; Bee flora; Seasonal management of bee colonies; Management of Robbing,

Swarming and Queenless colonies; Uniting and division of honeybee colonies; Queen rearing; Bees as pollinators and pollination management; Pests and Diseases of bees and their management; Hive products – Honey, Bee pollen, Bee wax, Propolis, Bee venom, Royal jelly and their extraction, processing, properties and uses; Poisoning of bees and its prevention; Economics of beekeeping.

Practical: Identification of honeybee species; Identification of honeybee castes and their stages; Study of nest architecture; Handling and inspection of bee colonies; Study of bee hives and bee keeping equipments; Dissection of worker bees to study different morphological structures; Dissection of worker bees to study different anatomical structures; Hiving of feral colony; Management of bee colonies - feeding, Prevention of swarming, robbing and absconding; Mass queen rearing technique; Fixing comb foundation sheet and providing of super chamber to the bee colonies; Uniting and dividing of colonies; Extraction and processing of honey; Testing of honey for its purity; Extraction and processing of other bee products; Study of bees as pollinators; Identification of bee flora;. Identification of bee pests and diseases; Visit to important apiaries and bee keeping societies around the region; Working out economics of beekeeping.

CROP PHYSIOLOGY

CPH. 211 Fundamentals of Crop Physiology 2+1

Theory:

Introduction: Importance of physiology in agriculture.

Plant-water relations: Structure, properties and functions of water; concept of diffusion, osmosis and water potential;

Water balance of plants: Water in soil; Water absorption and translocation in plant; soil-plant-atmosphere continuum; Theories explaining water translocation.

Transpiration: Significance of Transpiration; transpiration in relation to crop productivity, Stomatal physiology, Concept of water use efficiency.

Mineral Nutrition: Importance of plant nutrients; Classification of plant nutrients; Nutrient uptake- Soil, root and microbes interaction, Microbial association for improved uptake of nutrients; Functions of plant nutrients- Deficiency and toxicity symptoms of plant nutrients; Hydroponics, aeroponics. Mechanism of ion absorption and translocation. Membrane transporters and carriers.

Photosynthesis: Mechanism of carbon fixation by $C_{3,}$ C_4 and CAM pathway and their significance;Plant responses to elevated $CO_{2,/}$ climate change; Relation of photosynthesis and crop productivity; Starch and sucrose synthesis; Translocation of assimilates; Source and sink concept; Photorespiration; Factors affecting photosynthesis and productivity; Dry matter partitioning; Harvest index of crops.

Respiration: Significance; Respiratory metabolism, Alternative respiration, Factors regulating respiratory rates.

Plant Growth and Development: Concept of plant growth and morphogenesis; Growth and yield parameters and their measurments; Hormones and plant growth regulators in modulating crop growth;Physiological importance of Auxins, GA, Cytokinin, ABA, Ethylene, Brassinosteroids and strigolactones; biosynthesis and mode of action of plant hormones; applications of growth regulators in agriculture, horticulture and industry.

Photoperiodism and vernalization: Basic concepts and their relevance in crop productivity; Phytochromes and their role.

Seed dormancy and viability: Basic concepts,seed germination and seedling vigour.

Stress Physiology: Plant responses to abiotic stresses; key concepts and definition; acclimation and adaptation mechanisms.

Practical: Preparation of standard solutions; Methods of measuring water status in plant tissue; Determination of soil water status; Determination of stomatal frequency and index; Measurement of stomatal conductance and transpiration; Measurement of water use efficiency at single leaf level; Extraction, separation and quantification of photosynthetic pigments; Measurement of photosynthetic rate; Measurement of growth and yield parameters; Measurement of respiration rate; Deficiency symptoms of nutrients and their identification; growth hormone bioassay; Seed dormancy and methods to break seed dormancy; Measurement of Seed viability and seedling vigor; effect of moisture stress on seed germination and seedling vigor.

CPH. 221 Applied Plant Physiology and Crop Modeling 1+1

Theory

Application of growth regulators in agriculture/ horticulture/ forestry/industry: Effect of growth regulators on important plant growth and developmental processes. Synthetic growth regulators - classification and their effect on plant growth and development. Practical utility of application of plant growth regulators on farm.

Physiological basis of commercial micro propagation: Micro-propagation techniques and its application specific to growth modulation. Macro-propagation techniques including clonal multiplication of elite material. Haploids in crop improvement.

Mineral nutrition: Foliar/ soil application of nutrients to correct the deficiency symptoms. Bio-fortification of micronutrients and their importance in human health.

Herbicide physiology: Classification and mode of action of herbicide and their applications. Development of herbicide tolerant crops.

Post harvest physiology: Physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest shelf

life of cut flowers, vegetables and fruits. Hormonal and chemical control of post harvest deterioration of fruits, vegetables and cut flowers and its significance in storage and transport.

Seed physiology: Methods to break seed/ bud dormancy of important agriculture/ horticulture plants. Seed priming/ seed encapsulation techniques to improve seed germination and seedling vigour in important agriculture crops.

Drought mitigation strategies: Mechanism of drought adaptations. Plant traits linked to drought adaptation. Antitranspirants and their applications in agriculture, water holding polymers and their relevance

Crop modeling: Physiological yield models, plant ideotypes.

Practical: Growth regulator formulations for specific crops. Demonstration of plant growth hormones on important plant growth and developmental processes. Micro-propagation of commercially important crops. Techniques to develop deficiency symptoms of nutrients. Elemental analysis in plant tissues. Bio assay of herbicides. Mechanisms to enhance the uptake of herbicides. Identification of physiological maturity indices in important crops. Demonstration of anti-ethylene agent on shelf life of flowers/ fruits. Effect of growth regulators on delaying senescence/ ripening. Seed hardening techniques in cereal crops. Application of stable isotopes techniques in agriculture. Computer applications in plant physiology, crop productivity and modeling.

CPH. 222 Nanotechnology in Agriculture 0+1

Basic concepts of Nanoscience and Nanotechnology: Introduction, definition and meaning of nanotechnology, classification of nanomaterials, scientific revolutions –time and length scale in structures. Size effects on structure and morphology of nanoparticles. Synthesis of nano material: Physcial, chemical and biological methods. Role in social, economic, ethical and ecological spheres. Green nanotechnology.

Application of nanotechnology in Agriculture: Effects of seed priming and foliar applications of nanomaterial on growth and productivity of crops. Uptake and translocation of nanoparticles. Quantification of enahnced nano-nutrient content in edible parts. In vitro and field efficacy of nanoparticles (pesticides) against plant pathogens. Bioassy of nano-formulations of insecticide. Bio-safety of nano-formulations on natural enimes. Study the fate and behavior of nano fertilizers in soils. Application of nano technology in recycling of Agriculture waste. Safety, toxicity and adoption of nano particles in the soil and aquatic life. Nano sensors in agriculture-nutrient, water, soil.

FOOD SCIENCE AND NUTRITION

FSN. 111 Principles of Foods Science & Nutrition 2+0

Theory: Concepts of Food Science (definitions, measurements, density, phase, change, pH, Osmosis, Surface tension, colloidal systems etc.): Food composition and chemistry (water, carbohydrates, proteins, fats, vitamins, minerals, flavours, colours, miscellaneous bioactives, important reactions): Food microbiology (bacteria, yeast, moulds, spoilage of fresh & processed foods, Production of fermented foods); Principles and methods of food processing and preservation (use of heat, low temperature, chemicals, radiation, drying etc.); Food and nutrition, Malnutrition (over and under nutrition), nutritional disorders; Energy metabolism (carbohydrate, fat, proteins); Balanced/modified diets, Menu planning, New Trends in food science and nutrition.

FSN. 321 Food Processing, Food Safety Standards and Value Addition 1+1

Theory: : Status of food processing in India. Food processing and distinctive features of food commodities. Primary, secondary and tertiary processing. Processing of -cereals, legumes, fats and oilseeds,

fruits and vegetables, milk. Role of additives in value addition, packaging and labeling.

Food Safety- Definition, Importance, Scope and Factors affecting food safety, health risks, Types of hazards: Biological, Chemical, Physical hazards. Food storage, Hygiene and Sanitation. Sources of contamination and their control. Personal Hygiene. Food Safety management tools- basic concepts, PRPs, GHPs, GMPs, SSOPs etc. HACCP, ISO series and TQM. Food laws and Standards-Indian Food Regulatory Regime, FSSAI, Global Scenario- CAC, BIS, AGMARK

Practical: Processed and value added foods (cereals, pulses, fruits, vegetables).

Planning and preparation of weaning and supplementary foods. Planning of balanced diet. Development of teaching models for community nutrition education –

a) Protein energy malnutrition.

b) Micronutrient deficiencies

Preparation of different types of media. Microbiological examination of different food samples. Assessment of personal hygiene and surface sanitation. Preparation of plans for implementation HACCP.

FORESTRY AND ENVIRONMENTAL SCIENCE

FES. 111 Introduction to Forestry 1+1

Theory: Introduction–definitions of forest and forestry, branches of forestry, history and education of forestry in India. objectives of silviculture, forest classification, salient features of Indian Forest Policies and Acts. Forest regeneration, Natural regeneration - natural regeneration from seed and vegetative parts, coppicing, pollarding, root suckers; Artificial regeneration – objectives, choice between natural and artificial regeneration, essential preliminary considerations. Crown classification. Tending operations–weeding, cleaning, thinning–

mechanical, ordinary, crown and advance thinning. Forest mensuration–objectives, diameter measurement, instruments used in diameter measurement; Non instrumental methods of height measurement - shadow and single pole method; Instrumental methods of height measurement-geometric and trigonometric principles, instruments used in height measurement; tree stem form, form factor, form quotient, measurement of volume of felled and standing trees, age determination of trees. Indian wild life and management. Social forestry and its branches. Agroforestry – definitions, importance, criteria of selection of trees in agroforestry, different agroforestry systems prevalent in the country, shifting cultivation, taungya, alley cropping, wind breaks and shelter belts, home gardens. Cultivation practices of two important tree species of the region (Teak & Casurina).

Practical: Identification of tree-species, seedlings, seed and non-wood timber forest products. Diameter measurements using calipers and tape, diameter measurements of forked, buttressed, fluted and leaning trees. Height measurement of standing trees by shadow method, Pencil method, single pole method and hypsometer. Volume measurement of logs using various formulae. Nursery lay out, seed sowing, vegetative propagation techniques. Forest plantations and their management. Visits of nearby forest based industries or National park/Agroforestry system/JFPM.

FES. 221 Environmental Studies and Disaster Management 2+0

Theory: Multidisciplinary nature of environmental studies Definition, scope and importance. Natural Resources: Renewable and non-renewable resources and associated problems. a) Forest resources: Use and over-exploitation, deforestation, mining, and their effects on forest b) Water resources: Use and over-utilization of surface and ground water, dams-benefits and problems. c) Mineral resources: Use and exploitation, environmental effects of extracting and using

mineral resources. d) Energy resources: Growing energy needs, use of alternate energy sources. e) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.

Ecosystems: Ecological succession, Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and its conservation: - Introduction, definition, genetic, species & ecosystem. Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values. Biodiversity at global, National and local levels, India as a mega-diversity nation. Hot-spots of biodiversity. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Environmental Pollution: definition, cause, effects and control measures of: a. Air pollution b. Water pollution c. Soil pollution d. Marine pollution e. Noise pollution f. Thermal pollution. Solid Waste Management: causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution.

Social Issues and the Environment: From Unsustainable to Sustainable development, Urban problems related to energy, Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion. Wasteland reclamation. Consumerism and waste products. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Issues involved in enforcement of environmental legislation. Public awareness.

Human Population and the Environment: population growth, variation among nations, population explosion, Environment and human health: Role of Information Technology in Environment and human health.

Disaster Management: Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, avalanches, volcanic eruptions.

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, forest fire, road accidents, rail accidents, air accidents, sea accidents.

Disaster Management- Effect to mitigate natural disaster at national and global levels. International strategy for disaster reduction. Role of NGOs, and media. Central, state, district and local administration; Disaster response of Armed forces, Police and other organizations.

GENETICS AND PLANT BREEDING

GPB. 121 Fundamentals of Cytogenetics 1+1

Theory: Ultra structure of cell, cell organelles and their functions, structure of chromosome; chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; special types of chromosomes, chromosomal theory of inheritance-cell cycle and cell division- mitosis and meiosis and their significance. DNA: types, structure, replication, function, RNA: structure, types and function, life cycle of angiosperms: megasporogenesis and microsporogenesis and fertilization, structural and numerical variations in chromosome and their implications.

Practical: Study of microscope, study of cell structure, mitosis and meiosis cell division, preparation and use of fixatives and stains for microscopy, preparation of slides for identification of mitotic and meiotic stages,practice on mitotic and meiotic cell division, measurements of microstructures.

GPB. 211 Fundamentals of Genetics 1+1

Theory: Pre-and Post-mendelian concepts of heredity, Mendelian principles of heredity. Probability and -Chi-square. Types of dominance, epistatic interactions with examples. Multiple alleles, pleiotropism, Sex determination and sex linkage, sex limited and sex influenced traits, Blood group genetics, Linkage and its estimation, crossing over mechanisms, chromosome mapping. Mutation, classification, mutagenic agents and induction of mutation. Qualitative & Quantitative traits, Polygenes and continuous variations, multiple factor hypothesis, cytoplasmic inheritance. Protein synthesis, Transcription and translational mechanism of genetic material, gene concept: gene structure, function and regulation, Lac and Trptophan operons.

Practical: Solving problems on monohybrid, dihybrid, trihybrid, test cross and back cross, Solving problems on epistatic interactions including test cross and back cross, Concepts of probability and chi-square test and their application in genetics. Detection and estimation of linkage through two point test cross and three point test cross data. Solving problems of sex linkage.

GPB. 221 Fundamentals of Plant Breeding 2+1

Theory: Definition, history, objectives and accomplishments of plant breeding, modes of reproduction-its relevance on genetic consequences, breeding methods and cultivar options and its of plant breeding, pollination control systems-self-incompatibility and male sterility. Domestication, Acclimatization and Introduction; Centers of origin/diversity, **Plant genetic resources, their conservation and utilization, genetic** basis and breeding methods in self- pollinated crops - mass and pure line selection, components of genetic variation; heritability and genetic advance; hybridization techniques and handling of segregating populations; multiline concept, concepts of population genetics and Hardy-Weinberg Law, Genetic basis and methods of breeding cross pollinated crops, modes of selection; Population

improvement methods- Ear to row method, modified Ear to Row, recurrent selection schemes; heterosis and inbreeding depression, development of inbred lines and hybrids, composite and synthetic varieties; Breeding methods in asexually propagated crops, clonal selection and hybridization;; wide hybridization and pre-breeding; polyploidy in relation to plant breeding, mutation breeding-methods and uses; Breeding for important biotic and abiotic stresses; Biotechnological tools-DNA markers and marker assisted selection. Participatory plant breeding; Intellectual Property Rights, Patenting, Plant Breeders and & Farmer's Rights.

Practical: Plant Breeder's kit, Study of germplasm of various crops. Study of floral structure of self-pollinated and crospollinated crops. Emasculation and hybridization techniques in self & cross pollinated crops. Study of male sterility system. Methods of calculating mean, range, variance, standard deviation, heritability. Designs used in plant breeding experiments, analysis of Randomized Block Design, prediction of performance of double and three-way cross hybrids

GPB. 311 Crop Breeding 1+1

Theory: Centers of origin, distribution of species, wild relatives and major breeding objectives and procedures including conventional and modern innovative approaches for development of varieties and hybrids for improved yield, adaptability, stability, biotic and abiotic stress tolerance and quality (physical, chemical and nutritional) of different cereals-rice, wheat, maize, sorghum, bajra and ragi; pulses-redgram, breengram, blackgram, chickpea, soybean; oilseeds-sunflower, niger, groundnut, sesame, castor, rapeseed and mustard, fibre crops- jute and cotton; cash crops- sugarcane, potato and tobacco.

Practical : Floral biology, emasculation and hybridization techniques in cereals-rice, wheat, maize, sorghum, bajra and ragi; pulses-redgram, breengram, blackgram, chickpea, soybean; oilseeds- sunflower, groundnut, sesame, castor, rapeseed and mustard, fibre crops- jute

and cotton; cash crops- sugarcane, potato and tobacco. Estimation of heterosis, inbreeding depression and heritability; Layout of field experiments; study of quality characters, sources of genes of important characters; Visit to AICRP plots of different field crops.

GPB. 321 Intellectual Property Rights 1+0

Theory: Introduction and meaning of intellectual property, brief introduction to GATT, WTO, TRIPs and WIPO, Treaties for IPR protection: Types of Intellectual Property and legislations covering IPR in India:-Patents, Copyrights, Geographical indications, Trade secrets. Patents Act 1970 and Patent system in India, patentability, process and product patent, filing of patent, patent specification, patent claims, Patent opposition and revocation, infringement, compulsory licensing, Patent Cooperation Treaty, Patent search and patent database. Origin and history including a brief introduction to UPOV for protection of plant varieties, Protection of plant varieties under UPOV and PPV&FR Act of India, Plant breeder's rights, Registration of plant varieties under PPV&FR Act 2001, breeders, researcher and farmers rights. Traditional knowledge-meaning and rights of TK holders. Convention on Biological Diversity, International treaty on plant genetic resources for food and agriculture (ITPGRFA). Indian Biological Diversity Act, 2002 and its salient features access and benefit sharing.

HORTICULTURE

HRT. 121 Fundamentals of Horticulture and Fruit Crops Production 1+1

Theory: Horticulture - Definition and branches, Importance and scope, Classification of horticultural crops; Plant propagation - methods and propagating structures; Principles of orchard establishment; Principles and methods of training and pruning;

Unfruitfulness; Pollination, pollinizers and pollinators; Fertilization and Parthenocarpy; Importance of plant bio-regulators in horticulture; Importance of rootstocks; Origin, distribution, uses, area and production, soil and climatic requirements, commercial varieties/ hybrids, planting methods, nutrition, irrigation, weed management, pruning and training, inter and mixed cropping, harvesting and yield of Mango, Banana, Citrus, Grapes, Guava, Papaya, Sapota, Pineapple, Pomegranate and Jackfruit.

Practical: Identification of garden tools; Identification of fruits; Preparation of potting mixture; Layout and planting of orchard; Bearing habits; Propagation methods and physiological disorders of above fruits; Methods of irrigation and fertilizer application in above fruits; Visits to commercial orchards.

HRT. 211 Production Technology of Vegetable Crops 1+1

Theory: Importance of vegetables in human nutrition and national economy; Kitchen gardening; Origin, distribution, uses, area and production, soil and climatic requirements, commercial varieties/ hybrids, time of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, physiological disorders, harvesting and yield of Potato, Tomato, Brinjal, Chilli, Capsicum, Cucumber, Watermelon, Ridge gourd, Bitter gourd, French bean, Cabbage, Cauliflower, Onion, Garlic, Carrot, Radish, Palak, Amaranthus, and Drumstick. Protected cultivation of Capsicum and European Cucumber.

Practical: Identification of vegetables and their seeds; Study of morphological characters of different vegetables; Seed extraction; Seed viability tests; Nursery raising; Direct seed sowing and transplanting; Harvesting and grading of vegetables.

HRT. 221 Production Technology of Flower Crops and Landscaping 1+1

Theory: Importance and scope of flower crops; Classification of ornamental plants Principles of landscaping; Garden features and adornments; Garden styles and designs, Lawn and its maintenance; Protected cultivation of Rose, Gerbera, Carnation, Anthurium and Orchids; Open cultivation of Gladiolus, Tuberose, Chrysanthemum, Marigold, Jasmine, Aster and Crossandra.

Practical: Identification of Ornamental plants; Nursery bed preparation and seed sowing; Planning, designing and layout of garden; Physiological disorders of above flower crops; Post harvest handling of cut and loose flowers; Visit to commercial flower production units and nurseries

HRT. 311 Production Technology of Plantation Crops, Spices, Medicinal and Aromatic Plants 1+1

Theory: Origin, distribution, uses, area and production, soil and climatic requirements, commercial varieties, planting methods, nutrition, irrigation, weed management, inter and mixed cropping, harvesting and yield of Coconut, Arecanut, Cashew, Tea, Coffee, Rubber, Pepper, Cardamom, Ginger, Turmeric, Coriander and Fenugreek Ashwagandha, Aloe, Periwinkle, stevia, Mints, Lemongrass, Ocimum, Patchouli and Geranium.

Practical: Identification, propagation, physiological disorders, processing and value addition of above crops. Extraction methods for essential oils. Visits to commercial Plantation.

HRT. 321 Post Harvest Management and Value Addition of Fruits and Vegetables 1+1

Theory: Importance of post-harvest processing of fruits and vegetables; Extent and possible causes of post-harvest losses; Pre-

harvest factors affecting postharvest quality, maturity, ripening and changes occurring during ripening; Respiration and factors affecting respiration rate; Harvesting and field handling; Storage (ZECC, Cold storage, CA, MA and Hypobaric); Value addition concept; Principles and methods of preservation; Minimal processing; Intermediate moisture foods- Jam, Jelly, Marmalade – Concepts and Standards; Fermented and non-fermented beverages; Drying/ Dehydration of fruits and vegetables – Concept and methods; Canning - Concepts and Standards, Packaging of products.

Practical: Containers for shelf life extension; Effect of temperature on shelf life and quality of produce; Chilling and freezing injury in vegetables and fruits; Extraction and preservation of pulps and juices; Preparation of Jam, Jelly, RTS, Nectar, Squash, Wine, Fruit bar, Candy, Tomato products; Quality evaluation of products- physico-chemical and sensory; Visit to processing unit/ industry.

PLANT BIOTECHNOLOGY

PBT. 121 Fundamentals of Plant Biotechnology 2+1

Theory: : Concept of Plant Biotechnology – History of Plant Tissue Culture and Plant Genetic Engineering; Scope and importance in Crop Improvement – Totipotency and Morphogenesis, Nutritional requirements of *in-vitro* cultures; Techniques of i*n-vitro* cultures; Micro-propagation, Anther culture, Pollen culture, Ovule culture, Embryo culture, Endosperm Culture and its applications. Somaclonal variation: Types, Reasons. Somatic embryogenesis and synthetic seed production technology; Protoplast isolation, Culture, Manipulation and fusion; Products of somatic hybrids and cybrids, Applications in crop improvement. Genetic engineering: Restriction enzymes; vectors for gene transfer- Gene cloning, direct and indirect method of gene transfer, Transgenic plants and their applications. Blotting techniques- DNA finger printing, DNA based markers- RFLP, AFLP, RAPD, SSR and DNA probes. Marker-assisted selection and its recent advances.

Practical: Requirements for plant tissue culture laboratory; Techniques in plant tissue culture; Media components and preparations, Sterilization techniques and Inoculation of various explants; Aseptic manipulation of various explants; Callus induction and Plant regeneration; Micro-propagation of important crops, Anther, Embryo and Endosperm culture; Hardening/ Acclimatization of regenerated plants; Somatic embryogenesis and synthetic seed production; Isolation of protoplast, demonstration of culturing of protoplast, demonstration of isolation of DNA, Demonstration of gene transfer techniques-direct methods and indirect methods; Demonstration of confirmation of Genetic transformation, Demonstration of gel electrophoresis techniques. Restriction enzymes for digestion of DNA. Polymorphism, monomorphism, hybridity testing.

PLANT PATHOLOGY

PAT. 211 Fundamentals of Plant Pathology 2+1

Theory: Introduction: Importance of plant diseases, scope and objectives of Plant Pathology. History of Plant Pathology with special reference to Indian work. Terms and concepts in Plant Pathology. Cause and classification of plant diseases. Important plant pathogenic organisms, fungi, bacteria, fastidious vascular bacteria, phytoplasmas, spiroplasmas, viruses, viroids, algae, protozoa, phanerogamic parasites and nematodes with examples of diseases caused by them. Diseases and symptoms due to abiotic agents.Fungi: general characters, somatic structures, types of fungal thalli, fungal tissues, modifications of thallus, reproduction (asexual and sexual). Binomial system of nomenclature, rules of nomenclature. Classification of fungi, keys to phylum, classes, order and families.Bacteria and mollicutes: general morphological characters. Basic methods of classification and reproduction. Keys to major plant pathogenic bacterial genera. Viruses: nature, morphology, replication and transmission and classification of plant viruses. Keys to important plant virus families / genera.Nematodes: General morphology and reproduction, classification, keys to important plant

pathogenic nematode genera, symptoms and nature of damage caused by plant nematodes.Phanerogamic plant parasites: Common characteristic of important parasites, disease development, survival and spread. Growth and reproduction of plant pathogens. Liberation / dispersal and survival of plant pathogens. Types of parasitism and variability in plant pathogens. Pathogenicity: phenomenon of host infection by Fungi, Bacteria, Viruses, molicutes and nematodes. Pathogenesis**:** Penetration and colonization. Role of enzymes, toxins and growth regulators in disease development and their classification.Introduction to principles of plant disease management.

Practical: Acquaintance with various laboratory equipments and microscopy. Study of symptoms of various plant diseases caused by fungi, viruses, bacteria, nematodes and mollicutes. Field visit to get acquaint with plant disease symptom. Collection and preservation of plant disease specimens. Study of morphology of fungi, viruses, bacteria, nematodes and phytoplasma. Study of life cycle / disease cycle of major fungal, bacterial, viral, nematode and phanerogamic plant parasites diseases. Macroscopic and microscopic examination of plant pathogens including staining techniques for bacteria. Preparation of culture media and sterilization. Different methods of isolation and purification of fungi, bacteria, viruses and extraction of nematodes. Study of different methods of artificial inoculation / transmission and proving Koch's postulates for different plant pathogens. Study of liberation of fungal spore. Study of micrometry.

PAT. 221 Principles of Plant Disease Management 1+1

Theory: Defence mechanism in plants: structural, biochemical (pre and post-infection) and host plant resistances. Effect of pathogens on plant physiological processes viz., photosynthesis, respiration, translocation and transcription.Epidemiology: Epidemics and factors affecting disease development, patterns of epidemics and disease progress curves. Assessment of disease severity and crop losses. Survey, surveillance, remote sensing and forecasting of plant diseases.

Principles and methods of plant disease management: *Avoidance of the pathogen*: Choice of geographical area, selection of field and planting stock *etc., Exclusion of inoculum:* Plant quarantine regulations and inspections, post entry quarantine. *Eradication* of the pathogen: Cultural and physical methods of eradication and inoculum reduction; Biological methods of disease control: Crop rotation, use of trap crops, plant and plant products, use of biological control agents, mechanisms of biocontrol, cross protection. Breeding for disease resistance: Types of resistance, Development of resistant varieties, Induced resistance. Biotechnological approaches of diseases management. IPR and related issues. Chemical methods; nature, chemical combination, classification, mode of action and formulations of fungicides, bactericides, nematicides and antibiotics. Methods of application of chemicals. Insect vector management. Diagnosis of plant diseases. Seed pathology; importance of seed health to man and animals. seed borne nature of pathogens; Identification and detection of seed borne pathogens.

IDM: Introduction, history, importance & concepts. Economic importance diseases. Epidemiology and crop loss assessment methods with case studies. IDM module for important cereal (Rice), pulse (pigeon Pea), oil seeds (Sunflower and Groundnut) and vegetable (Tomato and Potato) and horticulture/plantation crops.

Practical: Methods of detection of different plant pathogens. Methods of estimation crop disease severity; Methods of estimation of crop losses; Methods of detection and identification of seed borne pathogens; Isolation of biocontrol agents; Testing the efficacy of biocontrol agents by dual culture technique. Mass multiplication of bioagents; methods of application of bioagents; Study of fungicides, bactericides, nematicides and their formulations. Preparation of Bordeaux mixture and calculation of fungicide spray concentration. Bioassay of fungicide and antibiotics. Methods of application of chemicals; Study of pesticide compatibility and their safe use; Study of plant protection equipment's. Methods of screening for disease resistances. Visit to pesticide companies.

PAT. 311 Diseases of Field Crops and their Management 2+1

Theory: Diseases of cereals, millets, pulses, oil seeds and cash crops with respect to economic importance, incidence, symptoms, etiology, disease cycle/life cycle and management practices. **Cereals and Millets:** Rice, Sorghum, Maize, Wheat, Bajra, Navane, & Ragi. **Pulses:** Pigeon pea, Chickpea, Blackgram and Greengram, Cowpea, & Soybean. **Oilseed crops:** Groundnut, Sunflower, Sesamum, Safflower, Mustard, Linseed, & Castor. **Cash crops:** Sugarcane, Cotton, Tobacco, Chilli, Ginger, Turmeric, & Mulberry. Important post-harvest diseases of field crops.

Practical: Study of symptoms, etiology and disease cycles / life cycles of selected diseases of field crops covered in theory. Field visit for the diagnosis of field problems. Collection and preservation of plant diseased specimens. Note: Students should submit 50 pressed and well mounted specimens.

PAT. 321 Diseases of Horticultural Crops and their Management 1+1

Theory: Diseases of fruit crops, plantation crops, vegetables crops, flower crops, Aromatic and Medicinal plants with respect to economic importance, incidence, symptoms, etiology, disease cycle/life cycle and management practices. **Fruit crops:** Mango, Apple, Papaya, Citrus, Guava, Pomegranate, Grapes, Pineapple Sapota, Peach &Banana. **Plantation crops:** Coffee, Tea, Rubber, Coconut, Arecanut, Cardamom, Beetle vine, Pepper & Vanilla. **Vegetable crops:** Tomato, Potato, Brinjal, Crucifers, Cucurbits, Bhendi, Leafy vegetable diseases, Carrot, Onion, Garlic, Cassava, Beans, Peas & Capsicum. **Flower crops:** Rose, Jasmine, Tuberose, Crossandra, Chrysanthemum & Gladioli. **Medicinal and Aromatic crops:** Periwinkle, Dioscorea, Solanum, Coleus, Davana, Citronella, Sandle, Geranium & Patchouli. Important post-harvest diseases of horticultural crops.

Practical: Study of symptoms, etiologyand disease cycle / life cycles of selected diseases of horticultural crops covered in theory. Field visit for the diagnosis of field problems. Collection and preservation of plant diseased specimens. Note: Students should submit 50 pressed and well mounted specimens.

SEED SCIENCE & TECHNOLOGY

SST. 311 Principles and Practices of Seed Production 1+1

Theory: Introduction to seed science and technology, seed and its importance. Seed quality – characteristics of quality seeds, factors affecting seed quality and its maintenance. History and development of seed industry, Seed programmes, types, planning and execution. Different classes of seed, generation system of seed multiplication, seed replacement and varietal replacement rates- seed multiplication ratio, seed renewal and seed plan, Agencies involved in seed production at state and national level. Seed certification – control of seed source, field inspection, field counts, field standards. Principles of seed production- genetic, agronomic and economic principles, Maintenance of genetic purity during seed production. Deterioration of crop varieties — factors and their control, Requirements for hybrid seed production and types of hybrids. Systems and techniques of hybrid seed production, male sterility, self incompatibility, CHA and EGMS. Planning for breeder, foundation, truthfully labelled and certified class of seed production. Seed production- foundation and certified seed production in maize (varieties, hybrids, synthetics and composites); rice, sorghum and bajra (varieties and hybrids); greengram, blackgram, bengalgram, cowpea (varieties) ; soybean, groundnut (varieties); sunflower (varieties and hybrids); castor (varieties and hybrids); cotton (varieties and hybrids); tomato and brinjal (varieties and hybrids): chilli and bhendi (varieties and hybrids), onion and melons and gourds (varieties and hybrids) and potato (varieties and true potato seeds), seed crop harvesting methods and management; Seed production under protected cultivation.

Seed marketing and distribution strategies– organizations, structures, sales, International trade. Export and import policies for seed trade, generation activities, sales promotional media and factors affecting seed marketing. Seed Sales, License, pricing policy, cost benefit ratio, economic feasibility and factors influencing.

Practical: Identification of seeds of agricultural/ horticulture crops.Study of seed structure in monocot and dicot seeds in agricultural and horticulture crops.Study of floral biology in self, cross and often cross pollinated crops.Identification of sex in gourds and melons.Identification of different varieties based on seed morphological characters in agriculture and horticulture crops.

Isolation types, measurement and determination in self and cross pollinated crops.Carrying out field inspection and taking field counts.Study of different contaminants and practicing rouging.

Practicing hybrid seed production techniques – hand emasculation and pollination.Practicing detassling techniques.Diagnostic identification of A, B and R lines in hybrid seed production.

Studies on planting ratio, border rows and synchronization and supplementary pollination techniques in hybrid seed production.Determination of physiological maturity in agri-horticultural crops.Visit to KSSOCA and grow out test farms.Visit to seed production plots (OPV and hybrids) of public and private organizations.Calculation of economics of seed production (OPV and Hybrids).Visit to seed production under protected cultivation.

SST. 321 Post Harvest Seed Technology and Quality Assurance 1+1

Theory: Introduction and importance of seed quality regulations-seed legislations and regulatory measures. Seeds Act (1966), Seed Rules (1968), Seed Control Order (1983), Central Seeds Committee, Central Seed Certification Board, OECD Seed Certification Schemes,

State Seed Certification Agency – Central and State Seed Testing Laboratories and their functions, New Seed Policy (1988), The plants, fruits and seeds (regulation of import into India), Order (1989). DUS testing principles and applications, PPV and FRA (2001 and 2003), National Seed Policy (2002) and the Seed Bill (2004). Seed Drying — importance, principles and methods. Psychrometric chart and its use in seed drying process. Seed processing — objectives and principles. Air screen cleaner and its working principles, different upgrading equipments and their use. Seed treatment- importance and types, equipments used for seed treatment, Seed testing — objectives, history, sampling procedures, testing for moisture, physical purity, germination, viability, vigour and seed health. Seed quality regulation systems (Grow out test and molecular markers). GM crop testing. Seed packaging — principles, procedures and types of containers. Varietal release, notification – seed certification, history, phases and procedures, field inspection, field counts, field and seed standards, Post harvest inspections and seed quality assurance. Seed storage - general principles, stages, factors affecting seed longevity, conditions required for safer storage, measures for humidity, moisture and temperature control, mid storage corrections and seed quality enhancement techniques.

Practicals: Study of instruments used in Seed testing laboratory.Visit to seed testing laboratories.Visit to seed processing plant.Study of air screen cleaner and upgrading machines. Practicing seed sampling methods in bulk and in containers.Conducting Physical purity test. Determination of seed moisture.Conducting standard germination test and seedling evaluation in agricultural crops.Assessment of seed viability through Tz test and Seed blending.Carrying out different vigor test.Conducting seed health test in agri-horticultural crops.Visit to grow out test plots.Determination of cultivar purity tests.Practicing pre-storage seed treatment and dormancy breaking methods.Studies on packaging types and methods.Visit to seed godowns and cold storage units.Visit to public and private (National and multinational) seed companies.

SERICULTURE

SER. 321 Introduction to Sericulture 1+1

Theory: Introduction,origin & history,statistics and distribution of sericulture, Mulberry varieties. Types of silks, Species of silkworms and their host plants. Raising of mulberry saplings, mulberry cultivation practices for irrigated and rainfed conditions, separate chawki garden. Intergrated nutrient Management.Pests and diseases of mulberry and their management. Life cycle of silkworms. Morphology and anatomy of *Bombyx mori* L.Commercially exploited breeds of silkworm. Steps in silkworm egg productionat grainage, egg sheets and loose egg production technology**.** Tier system of silkworm seed multiplication, seed area concept. Preservation and handling of eggs**,** egg incubation. Disinfection and hygiene in silkworm rearing**.** Silkworm rearing plan, Rearing house plan and equipments. Importance of chawki rearing, chawki rearing centres. Harvesting, transportation and preservation of leaves. Methods of silkworm rearing, shoot feeding, shelf rearing, raering operations, environmental conditions and their management. Importance of feeding, bed cleaning, spacing, care during moulting. Picking and mounting ripened silkworms. Harvesting of cocoons, grading, cocoon sorting, defective cocoons, and sale of cocoon in silk cocoon markets. Mechanization in sericulture. Pests and diseases of silkworms and their management. Post cocoon technology, Steps in reeling – storage- cocoon drying/stifling, cocoon cooking, brushing, reeling and re- reeling. Different methods of silk reeling. Raw Silk Marketing-Silk Exchange– functions, Silk trade -import-export**.** Sericulture byproducts and their utilization for additional income. Economics of Sericulture.

Practical: Mulberry varieties, Host plants of non-mulberry silkworms. Preparation of land, preparation of planting material and planting of mulberry, pruning, harvestingand storage of mulberry leaves. Pests and diseases of mulberry. Species of silkworms – life cycle of *Bombyx mori* L. Mulberry pests and diseases. Identification of cocoons of

important breeds. External morphology of life stages – egg-larva-pupa and moth of *Bombyx mori* L. Study of silk gland and digestive system of *Bombyx mori* L.Disinfectants - rearing bed and general disinfectants**.** Grainage techniques. Study of rearing house plan and equipments for shoot feeding and shelf rearing. Methods Incubation of silkworm eggs and brushing. Identification of silkworms settling for moult, at moult, out of moult. Feeding, bed cleaning and spacing. Identification and picking of ripe worms, mounting, types of mountages, cocoon harvesting and grading. Pests and diseases of mulberry silkworm. Single cocoon reeling, study of reeling equipment.

SOIL SCIENCE & AGRICULTURAL CHEMISTRY

SAC. 121 Fundamentals of Soil Science 2+1

Theory : Soil as a natural body, Pedological and edaphological concepts of soil; Soil genesis: soil forming rocks and minerals; weathering, processes and factors of soil formation; Soil Profile, components of soil; Soil physical properties: soil-texture, structure, density and porosity, soil colour, consistence and plasticity; Elementary knowledge of soil taxonomy classification and soils of India; soil survey, types, methods of soil survey Soil water retention, movement and availability; Soil air, composition, gaseous exchange, problem and plant growth, Soil temperature; source, amount and flow of heat in soil; effect on plant growth, soil organisms: macro and micro organisms, their beneficial and harmful effects;

Practical : Study of general properties of minerals, Study of silicate and non-silicate minerals, Study of igneous, sedimentary and metamorphic rocks, Study of soil sampling tools and collection of representative soil samples, Study of soil profile, Determination of soil moisture content, Determination of bulk density and particle density and porosity of soil, Study of soil texture by feel and bouyoucos method, Determination of soil colour, Study of capillary rise phenomenon of water in soil column and water movement in soil, Demonstration of heat transfer in soil, Study of soil map, Visit to NBSS&LUP.

SAC. 211 Soil Chemistry 1+1

Theory : Soil chemistry- Scope and importance . components of soils – inorganic and organic components. Soil colloids – types properties and significance of soil colloids. Layer silicate clays-genesis, structure and properties. Source of charges – positive and negative charges, electrical double layer – Helmholtz, Gouy – Chapman, stern theories. Ion exchange cation exchange capacity and anion exchange capacity, factors influencing ion exchange and its significance. Soil organic matter – composition, decomposition, fractionation of organic matter, uses; Humus – humic substances, nature and properties ; carbon cycle, C:N ratio;Chemistry of submerged soils.

Practical : Analytical chemistry – basic concepts, techniques and calculation; Determination of soil pH; Determination of electrical conductivity of soil; Determination of soil organic carbon; (Ca, Mg, K and Na); Determination of base saturation and exchangeable sodium percentage of soil.

SAC 311 Problematic Soils and their Management, Geoinformatics 1+1

Theory : Soil quality and health, Distribution of Waste land and problem soils in India. Soil reaction-pH, soil acidity and alkalinity, buffering, effect of pH on nutrient availability; Their categorization based on properties. Reclamation and management of Saline and sodic soils, Acid soils, Acid Sulphate soils, Eroded and Compacted soils, Flooded soils, Polluted soils - Soil pollution - behaviour of pesticides and inorganic contaminants, prevention and mitigation of soil pollution. Irrigation water – quality and standards, utilization of saline water in agriculture. Multipurpose tree species, bio remediation through MPTs of soils, land capability and classification, land suitability classification. Problematic soils under different Agro-ecosystems. Geo-informatics-definition, concepts, tool and techniques; their use in Precision Agriculture. Crop discrimination and Yield monitoring, soil mapping;

fertilizer recommendation using geospatial technologies; Spatial data and their management in GIS; Remote sensing concepts and application in agriculture; Image processing and interpretation; Global positioning system (GPS), components and its functions; Introduction to crop Simulation Models and their uses for optimization of Agricultural Inputs. Remote sensing and GIS in diagnosis and management of problem soils.

Practical : Determination of Soil pH, EC, ESP, CEC, LR, GR. Quality of irrigation water – Determination of anion, cation, SAR in irrigation water. study of topographical maps, Use of GPS, introduction to remote sensing and GIS,Visit to pesticides residue lab, visit to problematic soil site, visit to KSRSAC

SAC. 321 Manures, Fertilizers and Soil Fertility Management 2+1

Theory : Introduction and importance of organic manures, properties and methods of preparation of bulky and concentrated manures. Green/leaf manuring. Fertilizer recommendation approaches. Integrated nutrient management.

Chemical fertilizers: classification, composition and properties of major nitrogenous, phosphatic, potassic fertilizers, secondary & micronutrient fertilizers, Complex fertilizers, nano fertilizers Soil amendments, Fertilizer Storage, Fertilizer Control Order.

History of soil fertility and plant nutrition. criteria of essentiality. role, deficiency and toxicity symptoms of essential plant nutrients, Mechanisms of nutrient transport to plants, factors affecting nutrient availability to plants. Chemistry of soil nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and micronutrients. Soil fertility evaluation, Soil testing. Critical levels of different nutrients in soil. Forms of nutrients in soil, plant analysis, rapid plant tissue tests. Indicator plants. Methods of fertilizer recommendations to crops.

Factor influencing nutrient use efficiency (NUE), methods of application under rainfed and irrigated conditions.

Practical : Introduction of analytical instruments and their principles, calibration and applications, Colorimetry and flame photometry. Estimation of soil organic carbon, Estimation of alkaline hydrolysable N in soils. Estimation of soil extractable P in soils. Estimation of exchangeable K; Ca and Mg in soils . Estimation of soil extractable S in soils..Estimation of DTPA extractable Zn in soils. Estimation of N in plants. Estimation of P in plants. Estimation of K in plants. Estimation of S in plants. Analysis of Manures and fertilizers, Visit to STL/FTL.

STUDENT "READY" (RURAL ENTREPRENEURSHIP AWARENESS DEVELOPMENT YOJANA) PROGRAMME

Components of the programme :

i. Experiential Learning/Hands on Training / Skill Development Training

ii. Rural Agriculture Work Experience

iii. In Plant Training/ Industrial Attachment / Students Projects

I EXPERIENTIAL LEARNING

- To be offered during Eighth semester
- **0+20** Credit Hours
- Register for any of two modules
- Each module of **0+10** credit hours.

a) Concept

❖ 'Experiential' means that learning and development are achieved through personally determined experience and involvement.

- ❖ Experiential learning is a business curriculum related endeavour which is interactive.
- ❖ EL is for building (or reinforcing) skills in
  - o Project development and execution
  - o Decision-making
  - o Individual and team coordination
  - o Approach to problem solving
  - o Accounting, marketing and resolving conflicts etc.
- ❖ End to end approach.
- ❖ Carefully calibrated activities move participants to explore and discover their own potential.
- ❖ Both activities and facilitation play a critical role in enhancing team performance.

b) Objectives

- To provide excellent opportunity to develop analytical and entrepreneurial skills, and knowledge through meaningful hands on experience, confidence in their ability to design and execute project work.

The main objectives of EL are:

- To promote professional skills and knowledge.
- To build confidence and to work in project mode.
- To acquire enterprise management capabilities.

c) Duration

- ➢ 180 days (one semester) period in the final year.
- ➢ Students and faculty are expected to attend the activities even on institutional holidays with total commitment, and without any time limit or restriction of working hours.

d) Attendance

- ❖ Minimum attendance required is 85%.
- ❖ Any student in the event of recording shortage of attendance has to re-register the EL when offered next by paying the assigned fee.

e) Students' Eligibility

- ▪ To get the eligibility for registering the EL programme, the students should have completed all the courses successfully.
- ▪ Aassignment/allotment of the EL programme shall be based on merit of the student at the end of 5th Semester.

II RURAL AGRICULTURAL WORK EXPERIENCE

- To be offered during **S**eventh semester
- 0+20 credit hours in two parts: RAWE and AIA
- Attachment in University/ College/ KVK or a Research Station
- Helps the students primarily to understand the rural situations, status of Agricultural technologies adopted by farmers, prioritize the farmer's problems and to develop skills & attitude of working with farm families for overall development in rural area.
- Timings for RAWE can be flexible for specific regions to coincide with the main cropping season.

Objectives

- o To provide an opportunity to the students to understand the rural setting in relation to agriculture and allied activities.
- o To make the students familiar with socio-economic conditions of the farmers and their problems.
- o To impart diagnostic and remedial knowledge to the students relevant to real field situations through practical training.

- To develop communication skills in students using extension teaching methods in transfer of technology.
- To develop confidence and competence to solve agricultural problems.
- To acquaint students with on-going extension and rural development programmes.

MODULES FOR SKILL DEVELOPMENT AND ENTREPRENEURSHIP

A student has to register 20 credits opting for two modules of (0+10) credits each (total 20 credits) from the package of modules in the **VIII semester.**

Course No.	Course Title	Cr. Hrs.
ESE. 421	Commercial Sericulture	0+10
EAG. 421	Organic Production Technology	0+10
EAM. 421	Production Technology for Bio-fertllizers	0+10
EAM. 422	Mushroom Cultivation Technology	0+10
EAP. 421	Commercial Beekeeping	0+10
EAS. 421	Poultry Production Technology	0+10
EEP. 421	Production Technology for Bio-agents	0+10
EFS. 421	Food Processing	0+10
EHR. 421	Commercial Horticulture	0+10
EHR. 422	Floriculture and Landscaping	0+10
ESA. 421	Soil, Plant, Water and Fertilizer Testing	0+10
ESA. 422	Agriculture Waste Management	0+10
EST. 421	Seed Production and Technology	0+10

ESE. 421 Commercial Sericulture 0+10

Mulberry Cultivation: Raising of mulberry saplings, establishment of mulberry garden for rainfed, irrigated condition and exclusive chawki garden, manure and fertilizer schedule. Integrated Nutrient management, pruning practices, mechanization in mulberry cultivation, mulberry diseases and pests and their control measures.

Silkworm rearing: Planning and preparation for silkworm rearing, disinfection and hygiene in rearing house, different rearing appliances, egg transportation, egg incubation, harvest and leaf preservation, chawki rearing, late age silkworm rearing methods, bed spacing, feeding, care during moult. Silkworm diseases and pests and their management, mounting, harvesting, cocoon sorting, deflossing, transportation and marketing of cocoons. Mechanization in silkworm rearing.

Economics of mulberry cultivation and silkworm rearing. By-product utilization and value addition for additional income.

EAG. 421 Organic Production Technology 0+10

Production of Organic Manures: Green biomass production: Raising sunhemp, dhaincha, and other green manure crops in 500 m^2 area by each student. **Compost production:** VAT method of composting, structure requirement, substrates assembling, filling the VATS, watering, turning and removing the matured compost from the VATs,. **NADEP method of composting:** structure requirement, advantage over other composting methods, filling the substrates, watering. Judging the maturity of the compost. **Vermicompost production:** Structures in vermicompost production, earthworms-species, lifecycle, temperature, moisture and substrate requirements. Management aspects-size reduction of substrates, aeration, watering, protection of earthworms against natural enemies. Each student shall produce at least 0.5 tonne of vermicompost. Maturity of the

vermicompost, separation of worms from the compost and bagging. Value addition-enrichment with concentrated organic sources, microbial cultures, Quality analysis of different composts, standards of different composts. **Production of biodigested liquid manures:** Structure requirements, assembling green biomass, cattle dung and cattle urine, production and use of biodigested liquid manure. Value addition of Composts:- enrichment with concentrated organic nutrient sources, microbial consortia. Value addition of biodigested liquid manures. **Production of indigenous organic additives:** Panchagavya, Beejamruta, Jeevamruta and Vermiwash. **Organic crop production:** Commercial cultivation of crops by adopting organic farming practices. Individual students shall raise short duration crops such as field bean, french bean, baby corn, vegetable cowpea, onion and other appropriate short duration crops in 500sq m^2 area in the organic farming block maintained in the campus by following organic ways of nutrient and weed management and plant protection practices. **Organic certification:** Requirements for conversion from conventional farming to organic farming, **Certification:** Government and Non-Government agencies involved in certification, permitted and restricted materials in organic farming. Cares to be taken in harvesting, processing, packaging and storing of organic produce, labelling organic produce, Organic Logos used in organic produce packages. Preparation of the project report and presentation.

EAM. 421 Production Technology for Bio-fertilizers 0+10

Different types of biofertilizers and their role in plant nutrition. Acquaintance of laboratory and mass production equipments. Preparation of different culture media and sterilization techniques. Mother culture and starter culture production and their maintenance. Isolation and examination of freeliving heterotrophic and photo autotrophic nitrogen fixing bacteria from soil. Isolation and

examination of Associative Nitrogen fixing bacteria. Isolation and examination of root nodule bacteria from leguminous and non-legumonous plants. Study of Azolla -Anabaena symbiosis. Isolation and examination of phosphate/ potassium solubilizing microorganisms. Study of mycorrhizal symbiosis and method of mass production of arbuscular mycorrhizal fungi. Study of plant growth promoting rhizobacteria. Different formulations of biofertilizers, packing and storaging methods. Production technology for carrier based and liquid biofertilizers. Quality standards for biofertilizers. Role of microorganisms in bioconversion of agricultural wastes. Principles and methods involved in Compost making. Entrepreneurship development- preparation of project proposals for setting different capacity biofertilizer units.

EAM. 422 Production Technology for Mushrooms 0+10

Characteristics and morphological features of mushrooms; Types of mushrooms cultivated, Maintenance of mushroom laboratory, Equipments used in mushroom laboratory, Preparation of culture media, Pure culture techniques, Spore print preparation, Mother culture preparation of mushroom, Spawn production, Layout of mushroom houses, Cultivation of oyster mushroom and milky mushroom, Harvesting, Processing, Packing of mushrooms. Pests, diseases and abiotic stress of cultivated mushrooms, Project preparation for spawn production and mushroom cultivation, Exposure/visits to spawn and mushroom production centers.

EAP 421 Commercial Beekeeping (0+10)

Handling of bee colonies for acquainting with different castes, immature stages and different kinds of cells of honey bees. How, When and Where to start beekeeping. Ways for procuring bee colonies. Location of bee colonies in nature, hiving and transfer to

bee hive. Survey on Bee flora for profitable beekeeping. Seasonal management of honey bee colonies during different seasons of the year. Management of honey bees colonies during dearth/ lean period and honey flow season. Preparation of honey bee colonies for higher honey production. Swarming, robbing, queenlessness colonies and their management. Dividing and uniting of honey bee colonies. Pests and diseases of honey bees and their management. Mass queen rearing for multiplication of colonies. Extraction, processing, testing of honey for its purity, composition and uses of honey. Extraction, processing, properties and uses of bee wax. Extraction, processing and uses of other bee hive products such as royal jelly, propolis, bee venom and pollen. Preparation of value added bee hive products.Role of honey bees in crop pollination for increasing crop productivity. Maintenance of honey bee colony records. Working out economics of beekeeping.

EAS. 421 Poultry Production Technology 0+10

History and classification of Modern Poultry breeds –Mankind has been rearing Poultry for game, eggs meat and as a companion bird and providing food, nutrition & financial security. ***Archaeopteryx*** is said to be the origin for all modern class of birds Aves. It is said to have teeth ,tail like structure and used to fly. Wild jungle fowl from Southeast Asia is said to be the origin,however, the Red jungle fowl Gallus gallus is predominant. All the Four modern breeds belongs to Genus namely, ***Gallus*** and four species ***gallus, varius, sonneratti*** and ***lafayetti*** The general classification is based on the type for which they are maintained like Egg type, Meat type, Dual purpose and Game type .

The modern classification is based on the origin and has Four Classes namely ***English, American, Mediterranean and Asiatic. Egg – parts of egg and formation of egg .***In Nature, Egg is a complete

unit of all the nutrients required for development of an embryo. It has all the nutrients except Calcium, water soluble and fat soluble vitamins and is termed as unadulterated Shape of an egg is termed as ***prolate spheroid*** Pigments Ooporphyrins and Xanthophylls are responsible for shell and yolk colour, respectively.

Broiler and layer industry – COLOURED broiler rearing

The TWO distinct commercial activities are rearing birds for Meat and Egg. Poultry meat is the cheapest animal protein and has no religious stigma for it's use and has remained a favorite among all religions and regions globally. Broilers are meat type birds reared for 5-6 weeks which are tender, juicy, succulent , low in fat (lean meat) and nutritious. Thus a farmer can raise 5-6 crops in a year completely depending and earning livelihood. Broiler chicks are bred for faster growth achieving a growth of 2000g from a 40 g chick in 40 days ie. a growth of 50 times in 40days.A Feed Conversion Ratio (FCR) of 1.7-1.8 is achieved with a mortality rate of less than 2 %. Still the per capita poultry meat consumption is about 2 kgs against an ICMR recommendation of 15 kgs.India stands 4th in Poultry Meat production.

Layer farming- In poultry females are exclusively maintained commercially for Eggs (table eggs) for providing wholesome and nutritious eggs for use in various farms both in fresh and egg white and yellow in powder farms. A per capita consumption of 45 eggs is achieved against the recommendation of 180 eggs leaving a huge gap leaving scope for growth in layers.

Housing principles- Orientation, Brooder houses, grower houses, layer houses

The Poultry sheds are to be in elevated places, rat proofed, oriented in East-West direction enabling a good cross ventilation with a width of not more than 25 ft ,overhang of 2-2.5 ft and any required length. Gable type sheds with side wall of 8 ft & center height of 12 ft with

asbestos roofing is ideal. Quality water supply to be ensured. Depending upon the type /age of birds brooder ,grower & layer sheds are built. Care must be taken to spend least on sheds but ensure technical specifications.

Management practices – scientific principles, litter management feeding & watering, lighting and bio-security

Poultry farming is not only a science but also an art and incorporates the basics of birds behavior,needs and comforts that makes poultry a successful livestock business.right from brooding -providing heat initially for chicks (2-3 weeks),providing feed ***ad libitum*** ,cool and quality water,light for visibility, turning (raking) the litter to maintain it with optimum moisture –neither dusty that may lead to respiratory diseases or wet that may result in diseases. Sanitary and Bio security measures such as washing, disinfection, white wash, flaming, movement of workers,entry of vehicles and outsiders are to be monitored. Need based Feeding timely with right type of feeds restraining wastage is of paramount importance. Incase of broilers light during night for visibility and 8 hrs of artificial light in layers is essential for birds maturity and consistent maintenance of egg production at 1 ft.candle at bird level.

Poultry Nutrition and feeding principles- feed ingredients ,types of feed, feed formulation

In poultry nearly 70 % of the cost of production I on feed alone hence utmost care to be exercised in selection of feed ingredients, macro & micro nutrients, feed mixing depending upon the age of the birds. The require protein ,energy & other nutrients are provided by mixing various feed ingredients like maize, soya extract, cotton ,sunflower cake,rice polish, mineral mixture etc.,Types of feed are Broiler pre-starter,starter, finisher ration , grower and layer feeds. Standard Feeds are available in the market and a large farmer will have own feed mixing plant for better economics.

Common diseases and Vaccination programme- viral, bacterial, ecto & endo parasites

Various diseases and pests have to be checked using both prophylactic and curative measures. Timely vaccination, de worming, and preventive doses of medicine in feed as well a water are administered. We are having pellet vaccines for easy administration of vaccines. Bio securi

Marketing and Economics of Poultry production

Indian Poultry marketing is very interesting and 90-95 % of the birds are sold as Live and termed as WET market. Only a small portion is marketed as dressed, frozen , ready to cook meatHowever organization like NECC, NMPPB, Egg & Meat corporations have tried to contain, guide the industry which is contributing to the tune of about 60,000 crores providing food & nutrition security, employment both direct & indirect. It is highly unpredictable leaving Economists ,producers a well a consumers guessing.

EEP 421 Production Technology for Bio Agents 0+10

Biological Control; definition, history, prospectus & principles and important mile stones in biological control. Mass multiplication of important bio agents, predators, parasitoids, rearing of laboratory hosts for parasitoids, predators and pathogens, Mass multiplication of selected parasitoids such as *Trichogramma* sp., *Goniozus nephantidis, Bracon brevicornis, Cotesia plutella* etc., ; Predators (*Cryptolaemus montrouzieri, Chrysoperla carnea, Dipha aphidivora* etc., ; Insect Pathogens (Ha NPV, SL NPV, *Beauveria bassiana, Metarhizium anisopliae, Nomurea rileyi, Verticillium lecanii*,); Entomo pathogenic nematodes *Stinernema glaseri, Heterorhabditis* sp. Etc. Determination of cost of production of biocontrol agents. Visit to commercial units producing biocontrol agents.

Biological control; definition and introduction from Plant Pathology perspective, Methods of isolation of biocontrol agents *viz*., *Trichoderma, Pseudomonas, Bacillus,Paecilomyces* and *Verticillium* from rhizosphere soil, roots and foliage of different crop plants, their purification and cultural studies viz., growth phase, C, N, temperature and pH requirement. Methods of screening of biocontrol agents for their efficacy against selected fungal, nematode and bacterial plant pathogens. Interaction between different biocontrol agents. Evaluation of different solid and liquid growth media for mass multiplication. Study of methods for rapid multiplication. Formulation of mass produced biocontrol agents using different carrier and additives and packaging. Quality control: evaluation of formulated products for bioefficacy and longevity in different storage conditions. Methods of application of biocontrol agents viz., seed treatment, seedling dip, foliar application, soil application and their evaluation in vivo. Enrichment of organic manures and amendments with biocontrol agents.

EFS. 421 Food Processing 0+10

Importance of commercial processing, need for understanding market status and data analysis Different processing, methods Primary processed foods, Secondary processed foods and Tertiary processed foods. Grain quality assessment, Cereals, millets, Ragi, Wheat, Maize, Pulses, /legumes, Selection of grains: Test suitability of grains namely Rice, Wheat, Ragi, Maze, Pulses for processing as approved by (FDA/ FAO, HACCP/FSSAI, WHO/GOI/GOK/BIS/any other.) Indian regulatory agency. Primary processing of grains: dehusking /dehulling milling, roasting, popping, malting, etc. for grains, namely ragi, paddy, wheat, millets, maize, pulses, nuts, value added/fortified flours & foods: Energy food mix: Ragi/wheat maize/ millets. Malt drink, supplementary foods, fortified composite flour, and instant flour mixes. Techniques evaluation of products Physical, Sensory & Objective evaluation methods computing nutritive value. Food Safety measures : Hygiene/

sanitation/ standards/regulations related to grains & products based on suitable methods approved by FDA/FAO/WHO/ GOI/GOK/BIS/ any other Indian regulatory agency. Shelf life of products: Grain storage practices. Use of additives & Preservatives, Labeling & its importance. Market study of exiting labeled foods, Label designing/ Packaging its requirements. Development of RTE Foods, Flour based shelf stable snack foods. Acceptability testing, project plan & Presentation By students: Product design, Machinery and equipment material & marketing supply chain. Processing & recording/book keeping, costing. Value chain of raw materials: study existing practice in industry trough visit & interaction Milling industry procurement/ milling/ marketing system. Storage & testing of raw materials testing of function & behavior of raw materials & products. Familiarization of equipment and their role, functioning, operation techniques cleaning condition regulation, maintenance handling. Baked produces. Processing of bread by different methods, importance of RH/ Temperature/pH, baking & finishing, processing of rolls/pizza/rusk/ etc., serving Techniques. Processing of biscuits: Regular biscuits fiber rich (Different fiber).

Development of questionnaire for data collection. Market survey on the processed and health foods, Data computation and presentation. Industry Visits/ Food processing industries, Flourmills, Baking industries, Vegetable and fruits processing units. Student group activities.

EHR. 421 Commercial Horticulture 0+10

Study of importance, problems and prospectus of nursery industry. Study of high-tech nursery management practices, use of polyhouses and shade nets in planting materials production. Practice of propagation techniques of fruits, vegetables and plantation crops and care of nursery plants. Tissue culture techniques in rapid multiplication of horticulture crops. Practice of open and protected cultivation

techniques such as bed preparation, fumigation, mulching, drip irrigation, fertigation, training, pruning, foliar application of micronutrients and other special practices, plant protection measures, harvesting, grading and packaging of important vegetable crops. Practice of pruning and training methods, fertilizers application, foliar application of micronutrients and growth regulators, identification of symptoms of insect and disease infestation, plant protection measures, intercultural operations, harvesting, grading, marketing of important fruit crops. Roof top / terrace gardening. Practice of preparing processed products such as RTS, Jams, Ketchup, Pickles, etc., from fruits and vegetables. Estimation of cost of cultivation and economic feasibility studies of important vegetables and fruits. Visit to high tech nurseries, institutions and farmers field. Final evaluation and examination.

EHR. 422 Floriculture and Landscaping 0+10

Importance and scope of Floriculture and landscaping, practice of nursery techniques and management of ornamental crops. Propagation techniques for ornamental crops, nursery bed preparation, raising seedlings in protrays and poly bag. Production technology of flower crops like –China aster, Marigold, Tuberose and Gladiolus under open condition and Rose, Gerbera, Anthurium and Carnations under protected cultivation. Preparation of main field, application of FYM, fertilizer management, mulching, drip irrigation practices for open cultivation as well as protected cultivation. Special practices to be followed in flower crop production such as pinching, disbudding, pruning, training, desuckering, staking and wire netting etc., Maintenance of shrubs climbers and trees. Establishment of hedges, edges, flower beds and rockeries. Practices of Bonsai and flower arrangement. Establishment of Garden adornments and vertical gardens. Maintenance of lawn and its management. Visit to commercial nurseries, high tech floriculture units and farmer's field. Final evaluation and examination.

ESA. 421 Soil, Plant, Water Manure and Fertilizers Testing 0+10

Good laboratory practices (GLP)

Principles of analytical chemistry

Analytical techniques, concepts of gravimetry, concepts of titrimetry (volumetric), preparation of standard solution of an acid

Instruments used in soil, plant, water, manure and fertilizer analysis

Potentiometer (pH meter), Conductometer (EC bridge), Spectrophotometer, Flame photometer, Atomic Absorption, Spectrophotometer (AAS)

Soil Analysis

Collection and preparation of soils samples, study of soil profile, physical properties of soil, mechanical analysis (soil texture), International pipette method, Hydrometer method, Determination of soil texture by feel method, density of soil, Bulk density of soil, Particle density of soil, pore space of soil, soil colour, physic chemical properties of soil, pH of soil, EC of soil, Chemical properties of soil, organic matter in soil, cation exchange capacity (CEC) of soil, Major nutrients in soil, available nitrogen in soil, available Phosphorusin soil, available potassium in soil, Secondary nutrients in soil, Determination of exchangeable calcium and magnesium in soil, available sulphur in soil, Micronutrients in soil, available micronutrient cations in soil, available boron in soil, Problematic soils and amendments, Soil acidity and lime requirement, Determination of exchangeable acidity in soil, reserve acidity in soil, extractable aluminum in soil, lime requirement of acid on soil, Soil alkalinity and gypsum requirement, Determination of lime content of soil, carbonate and bicarbonate in soil, chloride in soil, carbonate and bicarbonate in soil, chloride in soil, sodium in soil, gypsum requirement of alkali soil

Irrigation Water Analysis

Irrigation water sampling, Determination of pH irrigation water, electrical conductivity of irrigation water, carbonate and bicarbonate in irrigation water, chloride in irrigation water, calcium and magnesium in irrigation water, sodium in irrigation water, Computation of SAR and RSC of irrigation water, Determination of boron in irrigation water.

Waste Water Analysis

Collection and preservation of waste water samples, Analysis of different parameters of waste water, Determination of pH of waste water, EC in waste water, carbonate and bicarbonate in waste water, chloride in waste water, calcium and magnesium in waste water, potassium and sodium in waste water, Phosphorus in waste water, sulphur in waste water, acidity of waste water, total, suspended and dissolved solids in waste water, nitrate in waste water, dissolved oxygen in waste water, biological oxygen demand in waste water, chemical oxygen demand in waste water

Plant Analysis

Sampling handling and preparation of plant sample, Determination of Nitrogen in plant sample, Digestion of plant sample for estimation of nutrients (except nitrogen), Determination of phosphorus in plant sample, potassium in plant sample, calcium and magnesium in plant sample, sulfur in plant sample, micronutrients in plant sample

Organic Manure Analysis

Determination of pH of manure, EC of manure, organic carbon in manure, nitrogen in manure, Digestion for estimation of other nutrients in manure, Determination of phosphorus in manure, potassium in manure, calcium and magnesium in manure, sulfur in manure, micronutrients in manure

Fertilizer Analysis

Fertilizer sampling, Qualitative test for identification of fertilizer, Detection of adulterants in fertilizer, Estimation of ammonium nitrogen (NH_4 - N) in ammonium fertilizer, nitrate nitrogen (NO_3-N) in nitrate fertilizer, amide nitrogen (NH_2-N) in amide fertilizer (urea), Determination of biuret content of urea, Estimation of phosphorus in phosphatic fertilizer, Determination of potassium in potassic fertilizer.

ESA. 422 Agriculture Waste Management / Management of organic resources in Agriculture 0+10

- Collection of crop residues – bulky organic residues, concentrated organic residues. Green manuring. Agro industrial waste urban waste, sewage and sludge.
- Composting of organic residues. Conventional and mechanized techniques of composting.
- Vermicomposting of organic residues.
- Biogas preparation using organic resource
- Analysis of physical, chemical, biological and biochemical properties of different compost and spent slurry.
- Evaluation of different types of compost and spent slurry through field study and analysis of soil and crop data and presentation of soil test results and submission of report.

EST. 421 Seed Production Technology (0+10)

1. Principles of seed production in self and cross pollinated crops
2. Land preparation and management of seed production in maize, sunflower, tomato / chilli, soybean
3. Seed production techniques in cereals, pulses, oilseeds and vegetable crops

4. Seed production techniques in hybrids and varieties

5. Seed certification principles and procedures
   - Phases of seed certification
   - Field inspections
   - Rejection of seed field
   - Awarding the labels and tags
   - Indian minimum seed certification standard for important field crops

6. Harvesting of seed crop, physiological maturity index and methods of harvesting, and threshing

7. Seed processing and drying

8. Seed testing methods and procedures
   - Seed sampling, method of sampling and procedures
   - Seed germination
   - Seed moisture determination
   - Physical purity analysis
   - Seed vigour and viability
   - Seed health testing methods
   - Genetic purity testing

9. Seed treating methods and procedures

10. Seed storage and methods of storability

11. Seed marketing channels in Karnataka

12. Visit to seed production fields and seed industries

Evaluation of Experiential Learning (EL) / Hands on Traning (HoT) Programme

Sl.No.	Parameters	Max. Marks
1.	Project Planning and Writing	10
2.	Presentation	10
3.	Regularity	10
4.	Monthly Assessment	10
5.	Output delivery	10
6.	Technical Skill Development	10
7.	Entrepreneurship Skills	10
8.	Business networking skills	10
9.	Report Writing Skills	10
10.	Final Presentation	10
	Total	**100**

EVALUATION OF STUDENT READY PROGRAM

- Students shall be evaluated component-wise under village attachment/ agro-industrial attachment/ hands on training/skill development training/experiential learning/student projects.
- Each College of the University will designate a Student READY Program Coordinator and component wise evaluation committees. These committees will evolve a method of evaluation depending upon the component undertaken giving due weightage to the observations made by the Scientists/Agro-industrial Officer and the Program Coordinator with whom they are attached.

- Since the Credit Hours allotted to the Student READY program are gradial, the minimum condition of attendance and grading system will apply for the program as will be applicable to other courses.
- It is expected that at the end of Student READY program, the students should gain competency for entrepreneurship, which should be innovative and creative in nature. The evaluation committee must ensure percentage increase in this competency at the end & successful organization of all Student READY programs.

Educational Tour

One Educational Tour for 15 days during break period after the V Semester shall be conducted and grading shall be done as Satisfactory/ Non Satisfactory.

EXAMINATION AND EVALUATION SYSTEM

Declaration of division(I, II and III divisions, distinctions etc.) in the degree certificate to be made compulsory by all Universities:

1 Examination

- External theory (50%)
- Internal Theory + Practical (50%)
  - **Courses with Theory and Practical**
    Mid-term Exam (30%) + Assignment (5%) in practical oriented courses + Practical (15%)
  - **Courses with only Theory**
    Mid-term Exam (40%) + Assignment (10%)
  - **Courses with only Practical**:
    (100%) Internal

- Paper to be set by external: HOD shall ensure the coverage of syllabus. If needed moderation can be done.
- Evaluation to be done **i**nternally by the faculty other than the Course Instructor. Syllabus of the concerned course shall be sent to the external examiner, who shall prepare the question papers. For practical, it is recommended that examination shall be conducted by course instructor(s) and one teacher nominated by HOD.

2. Evaluation

Percentage of Marks Obtained	Conversion into Points	OGPA	Division
100	10 Points		
90 to <100	9 to < 10	5.000 – 5.999	Pass
80 to <90	8 to < 9	6.000 – 6.999	II division
70 to <80	7 to < 8		
60 to <70	6 to < 7	7.000 – 7.999	I division
50 to <60	5 to < 6	8.000 and above	I division with distinction
<50 (Fail)	< 5		
Eg. 80.76	8.076		
43.60	4.360		
72.50 (but shortage in attendance)	Fail (1 point)		

GPA = Total points scored / Total credits (for 1 semester)

CGPA = Σ Total points scored / Course credits

OGPA = Σ Total points scored (after excluding failure points) / Course credits

% of Marks = OGPA x 100/10

UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

COURSE SYLLABUS
FOR
MASTER'S DEGREE PROGRAMME

2022-23

DIRECTORATE OF POST GRADUATE STUDIES
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CONTENTS

Unit 1: Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, Trace of matrices rank and inverse of matrices. Special matrices – idempotent, symmetric, orthogonal. Eigen values and eigen vectors, Spectral decomposition of matrices.

Unit 2: Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker sum of matrices. Sub-matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix. Solutions of linear equations, Equations having many solutions.

Unit 3: Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of vectors and matrices, Quadratic forms.

Practical

Solving problems on above topics

References

- ASCHBACHER M. 2000. *Finite Group Theory*. Cambridge University Press.
- DEO N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.
- GENTLE JE. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.
- GRAYBILL FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.
- HADLEY G. 1969. *Linear Algebra*. Addison Wesley.

AST 574 TIME SERIES ANALYSIS 2(1+1)

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios

based on time series data. It would also help them in understanding the concepts involved in time series data presentation, analysis and interpretation.

Theory

Block– I : Introduction to Time Series and its Models

Unit 1: Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis.

Unit 2: Linear stationary models: Autoregressive, moving average and mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes.

Block - II: Forecasting and Model Selection Criteria

Unit 1: Forecasting: Minimum mean square forecasts and their properties, calculating and updating forecasts.

Unit 2: Model identification: Objective:::s, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

Practical

- Time series analysis, autocorrelations, correlogram and periodogram;
- Linear stationary model; Linear non-stationary model; Model identification and model estimation;
- Intervention analysis and outlier detection.

References

- BOX GEP, JENKINS GM AND REINSEL GC. 2007. *Time Series Analysis: Forecasting and Control*. 3rd Ed. Pearson Edu.
- BROCKWELL P.J AND DAVIS R.A. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.
- CHATTERJEE S, HADI A AND PRICE B.1999. *Regression* Analysis by Examples. John Wiley.

- DRAPER N. R AND SMITH H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- JENKINS, G. M, REINSEL, G. C, GRETA M. L,GEORGE E.P.B. 2015. *Time Series Analysis: Forecasting and Control*, Wiley Series in Probability and Statistics.
- JOHNSTON J. 1984. *Econometric Methods*. McGraw Hill.

M.Sc. (Agri.) in Agronomy

Course Code	Course Title	Credit Hours
AGR 501	Modern Concepts in Crop Production	3 (3+0)
AGR 502	Principles and Practices of Soil Fertility and Nutrient Management	3 (2+1)
AGR 503	Principles and Practices of Weed Management	3 (2+1)
AGR 504	Principles and Practices of WaterManagement	3 (2+1)
AGR 505	Conservation Agriculture	2 (1+1)
AGR 506	Agronomy of Major Cereals andPulses	2 (1+1)
AGR 507	Agronomy of Oilseed, Fibre and Sugar Crops	3 (2+1)
AGR 508	Agronomy of Medicinal, Aromatic & Underutilized Crops	3 (2+1)
AGR 509	Agronomy of Fodder and Forage Crops	3 (2+1)
AGR 510	Agrostology and Agro- Forestry	3 (2+1)
AGR 511	Cropping System and Sustainable Agriculture	2 (2+0)
AGR 512	Dryland Farming and Watershed Management	3 (2+1)
AGR 513	Principles and Practices of Organic Farming	3 (2+1)
AGR 514	Research Techniques in Agronomy	2 (1+1)
	Total	**38 (26+12)**
AGR 580	Qualifying	2 (0+2)
AGR 581	Seminar - I	1 (0+1)
AGR 582	Seminar - II	1 (0+1)
AGR 591	Research - I	13 (0+13)
AGR 592	Research - II	14 (0+14)

AGR 501 MODERN CONCEPTS IN CROP PRODUCTION (3+0)

Objective

To teach the basic concepts of soil management and crop production.

Theory

Block I: Agro-biological principles

Unit 1: Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit 2: Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit 3: 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.

Block II: Scientific principles of crop production

Unit 1: 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 2: 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.

References

- BALASUBRAMANIYAN, P. AND PALANIAPPAN, S. P., 2001, *Principles and Practices of Agronomy*. Agrobios.
- FAGERIA N. K. 1992. *Maximizing Crop Yields*. Marcel Dekker.
- HAVLIN J. L., BEATON J. D., TISDALE S. L. AND NELSON W. L. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.
- PARODA R. S. 2003. *Sustaining our Food Security*. Konark Publ.

- REDDY, . S. R., 2000. *Principles of Crop Production*. Kalyani Publ.
- SANKARAN S. AND MUDALIAR T. V. S. 1997, *Principles of Agronomy*. The Bangalore Printing & Publ.
- SINGH S. S. 2006, *Principles and Practices of Agronomy*. Kalyani.
- ALVIN P. T. AND KOZLOWSKI T. T. (ed.). 1976, *Ecophysiology of Tropical Crops*. Academia Pul., NewYork.
- GARDNER P. P, PEARCE G. R. AND MITCHE LLRL. 1985, *Physiology of Crop Plants*. Scientific Pub. Jodhpur.
- LALR., 1989, *Conservationtillage for sustainable agriculture: Tropic sversus Temperate Environments*. *Advances in Agronomy*42:85-197.
- WILSIE C. P. 1961, *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.

AGR 502 PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT (2+1)

Objective

To impart knowledge of fertilizers and manures as sources of plant nutrients and appraise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

Block 1: Basic concepts of Soil fertility and Essential plant nutrients

Unit 1: 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 2: Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Block 2: Manures and Fertilizers

Unit 1: Preparation and use of farmyard manure, compost, green

manures, vermi compost, bio fertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

Unit 2: 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 3: 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 vermi-compost and residue wastes in crops.

Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Determination of selected micronutrients in soil & plant
- Computation of optimum and economic yield

References

- BRADY, N.C AND WEIL, R.R. 2002. *The Nature and Properties of Soils.*13th Ed. Pearson Edu.
- FAGERIA, N.K, BALIGAR, V.C AND JONES, C.A. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.
- HAVLIN, J.L, BEATON, J.D, TISDALE S.L AND NELSON W.L. 2006. *Soil Fertility and Fertilizers.*7thEd. Prentice Hall.
- PRASAD, R AND POWER, J.F. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

• YAWALKAR, K. S, AGRAWAL, J. P AND BOKDE S. 2000. *Manures and Fertilizers*. Agri-HortiPubl.

AGR 503 PRINCIPLES AND PRACTICES OF WEED MANAGEMENT (2+1)

Objective

To familiarize the students about the weeds, herbicides and methods of weed control.

Theory

Block I: Weed ecology and classification

Unit 1: Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and management; weed indices, weed shift in different eco-systems.

Unit 2: Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit 3: 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 allelo chemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance crops, residue, persistence and management; development of herbicide resistance in weeds and their management, herbicide combinations and rotation.

Block II: Weed management in crops

Unit 1: 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 2: Integrated weed management; recent developments in weed management- robotics, use of drones and aeroplanes, cost: benefit analysis of weed management.

Practical

- Identification of important weeds of different crops, Preparation of a weed herbarium, 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.
- Bioassay of herbicide resistance and residues,
- Calculation of herbicide requirement

References

- BÖGER, PETER, WAKABAYASHI, KO, HIRAI, KENJI (Eds.). 2002. *Herbicide Classes in Development*. *Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.
- CHAUHAN, B AND MAHAJAN, G. 2014. *Recent Advances in Weed Management*. Springer.
- DAS, T. K. 2008. *Weed Science :Basics and Applications*, Jain Brothers (New Delhi).
- FENNIMORE, STEVEN, A. AND BELL, CARL. 2014. *Principles of Weed Control*, 4thEd, California Weed Sci . Soc.
- GUPTA, O. P. 2007. *Weed Management*: *Principles and Practices*, 2ndEd.
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- MONACO, T. J, WELLER, S. C. AND ASHTON, F. M. 2014. *Weed Science Principles and Practices*, Wiley
- POWLES, S. B AND SHANER, D. L. 2001. Herbicide Resistance and World Grains, CRC Press.

- WALIA, U. S. 2006. *Weed Management*, Kalyani.
- ZIMDAHL, R.L.(ed).2018. *Integrated Weed Management for Sustainable Agriculture, B.D.Sci.Pub.*

AGR 504 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT (2+1)

Objective

To teach the principles of water management and practices to enhance the water productivity

Theory

Block I: Water resources and its utilization

Unit 1: Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit 2: Field water cycle, water movement in soil and plants; transpiration; soil-water plant 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 losses.

Unit 3: 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.

Block II: Water management in crops and cropping systems

Unit 1: 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 2: 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 3: Quality of irrigation water and management of saline water for irrigation, water management in problem soils.

Unit 4: Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit 5: Hydroponics

Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head method
- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity
- Estimation of upward flux of water using tensiometer and from depth ground water table

References

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AGR 505 CONSERVATION AGRICULTURE (1+1)

Objective

To impart knowledge of conservation agriculture for economic development.

Theory

Block I: Basic concepts of conservation agriculture

Unit 1: Conventional and conservation agriculture systems, sustainability concerns, conservation agriculture: Historical background and present concept, global experiences, present status in India.

Unit 2: Nutrient management in CA, water management, weed management, energy use, insect-pest and disease management, farm machinery, crop residue management, cover crop management.

Block II: Impact of conservation agriculture

Unit 1: Climate change mitigation and CA, C-sequestration, soil health management, soil microbes and CA.

Unit 2: CA in agro forestry systems, rainfed / dryland regions.

Unit 3: Economic considerations in CA, adoption and constraints, CA: The future of agriculture

Practicals

- Study of long-term experiments on CA,
- Evaluation of soil health parameters,
- Estimation of C-sequestration,
- Machinery calibration for sowing different crops, weed seed bank estimation under CA, energy requirements, economic analysis of CA.

References

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AGR 506 AGRONOMY OF MAJOR CEREALS AND PULSES (1+1)

Objective

To impart knowledge of crop husbandry of cereals and pulse crops.

Theory

Block I: Production technology of cereals

Unit 1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Rabi* cereals.

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Kharif* cereals.

Block II: Production technology of pulses

Unit 1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Rabi* pulses.

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Kharif* pulses.

Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities

- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- 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)
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out of harvest index of various crops
- Study of seed production techniques in selected crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

References

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- KHARE, D. AND BHALE M. S. 2000. *Seed Technology*. Scientific Publ.
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AGR 507 AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS (2+1)

Objective

To teach the crop husbandry of oil seed, fiber and sugar crops

Theory

Block I: Production technology of oilseeds

Unit1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of *rabi* oilseeds – Rapeseed and mustard, Linseed and Niger

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of *kharif* oilseeds - Groundnut, Sesame, Castor, Sunflower, Soybean and Safflower

Block II: Production technology of fiber and sugar crops

Unit 1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of Fiber crops - Cotton, Jute, Ramie and Mesta.

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of Sugar crops – Sugar-beet and Sugarcane.

Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing,

wrapping and propping of sugarcane

- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc.,)
- 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)
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fiber of different fiber crops
- Study of seed production techniques in various crops
- Visit to field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

References

- DAS, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.
- LAKSHMI KANTAM N. 1983. *Technology in Sugar cane Growing*. 2nd Ed. Oxford&IBH.

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AGR 508 AGRONOMY OF MEDICINAL, AROMATIC AND UNDER UTILIZED CROPS (2+1)

Objective

To acquaint students about different medicinal, aromatic and underutilized field crops, their package of practices **and processing**

Theory

Block I: Cultivation practices of medicinal plants

Unit 1: Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

Unit2: Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, Aloe vera, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, Nuxvomica, Rosadle, etc).

Block II: Cultivation practices of aromatic plants

Unit1: Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemongrass, Rose, Patchouli, Geranium).

Unit 2: Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Cluster Sbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

Unit 3: Post harvest handling–drawing, processing, grading, packing and storage, value addition and quality standards in herbal products.

Practical

• Identification of crops based on morphological and seed characteristics

- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.

References

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AGR 509 AGRONOMY OF FODDER AND FORAGE CROPS (2+1)

Objective

To teach the crop husbandry of different forage and fodder crops along with their processing.

Theory

Block I: Adaptation and distribution of fodder and forage crops

Unit1: Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum, maize, bajra, guar, cowpea, oats, barley, berseem, senji, lucerne, Indian sweet clover. etc.

Unit2: Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops / grasses, Napier grass, Panicum, Lasiuras, Cenchrus,etc.

Block II: Harvesting and processing of fodder and forage crops

Unit1: Year-round fodder production and management, preservation and utilization of forage and pasture crops.

Unit2: Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder. Fodder production through hydroponics. Azolla cultivation.

Unit3: Economics of forage cultivation uses and seed production techniques of important fodder crops.

Practical

- Practical training of farm operations in raising fodder crop;
- Canopy measurement, yield, leaf: stem ratio and quality estimation, *viz.* Crudeprotein, NDF, ADF, lignin, silica, cellulose and IVDMD, *etc.* of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation.

References

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- DAS, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.
- NARAYANAN, T. R. AND DABADGHAO, P.M. 1972. *Forage Crops of India*. ICAR.

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AGR 510 AGROSTOLOGY AND AGRO-FORESTRY (2+1)

Objective

To teach crop husbandry of different forage, fodder and agro forestry crops / trees along with their processing.

Theory

Block I: Agrostology

Unit1: Agrostology: definition and importance; principles of grassland ecology: grassland ecology–community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

Unit 2: Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

Block II: Agro-forestry

Unit 1: Agro-forestry: definition and importance; agro-forestory systems, agri silviculture, silvipasture, agri silvipasture, agri horticulture, aqua silviculture, alley cropping and energy plantation.

Unit 2: Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in

agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical

- Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination of farm vegetation
- Methods of propagation/ planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvi pastroal systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry research stations

References

- CHATTERJEE, B. N AND DAS, P. K. 1989. *Forage Crop Production. Principles and Practices.* Oxford & IBH.
- DABADGHAO, P. M AND SHANKARANARAYAN, K. A. 1973. *The Grass Cover in India*. ICAR.
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AGR 511 CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE (2+0)

Objective

To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

Theory

Block I: Cropping Systems

Unit1: Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

Unit 2: Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under mono culture cropping, multiple cropping, alley cropping, sequential cropping and inter cropping, mechanism of yield advantage in inter cropping systems.

Unit 3: Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in inter cropping, role of non-monetary.

Block II: Approaches for sustainability

Unit 1: Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

Unit 2: Plant ideo types for dry lands; plant growth regulators and their role in sustainability.

Unit 3: Artificial Intelligence-Concept and application.

References

- PANDA, S. C. 2017. *Cropping Systems and Sustainable Agriculture.* Agrobios (India)
- PANDA, S. C. 2018. *Cropping and Farming Systems*. Agrobios.

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AGR 512 DRYLAND FARMING AND WATERSHED MANAGEMENT (2+1)

Objective

To teach the basic concepts and practices of dry land farming and soil moisture conservation.

Theory

Block I: Concept and characteristics of dry land farming

Unit 1: Definition, concept and characteristics of dry land farming; dry land versus rain fed farming; significance and dimensions of dry land farming in Indian agriculture.

Unit 2: 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 3: 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.

Block II: Moisture conservation practices

Unit 1: 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 2: Concept of watershed resource management, problems, approach and components.

Practical

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

References

- REDDY, T. Y. 2018. *Dryland Agriculture Principles and Practices*, Kalyani publishers
- DAS, N. R. 2007. *Tillage and Crop Production*. Scientific Publ.
- DHOPTE, A. M. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.
- DHRUV NARAYAN V, V. 2002. *Soi land Water Conservation Research in India*. ICAR.
- GUPTA, U. S. (Ed.). 1995. *Production and Improvements of Crops for Dry lands*. Oxford & IBH.
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AGR 513 PRINCIPLES AND PRACTICES OF ORGANIC FARMING (2+1)

Theory

Block I : Principles and Practices of Organic farming

Unit I : Organic farming - concept and definition, its relevance to Indian and global agriculture and future prospects; principles of organicagri culture; 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, organicresidues, organic manures, composting, soil biota and decomposition of organicresidues, earthworms and vermicompost, green manures, bio-fertilizers and biogastechnology.

Block I : Cultivation practices underOrganicfarming

Unit III : Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping inrelation to maintenance of soil productivity.

Unit IV : Control of weeds, diseases and insectpest management, biological agents and pheromones, bio-pesticides.

Unit V : Socio-economicim pacts; marketing and eXport potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Method of making compost by aerobic method
- Method of making compost by an aerobic method
- Method of making vermi compost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium
- Cultures, use of Azotobacter, Azospirillum and PSB cultures in field
- Visit to abiogas plant
- Visit to anorganic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

BLOCK II: Methods of Machine Learning

Unit I: Introduction to Machine Learning methods: Dimensional Reduction Techniques, Methods of Feature Selection, Resampling Techniques, Elements of Text Mining and Web Mining, Soft Computing and Fuzzy logic system and application in bioinformatics.

Practical's

- Decision tree, classification techniques: ANN, SVM, KNN,
- Case based reasoning and its applications on biological data.
- Clustering techniques; Clustering of high dimensional data;
- Dimensional reduction techniques;
- Resampling techniques;
- Text mining and Web mining.
- Soft Computing and Fuzzy logic system & application in bioinformatics.

Reference

- Witten, H.I., Frank, E. and Hall, M.A. 2011. Data Mining: Practical Machine Learning Tools and Techniques.
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- Clarke, S.B., Fokoue, E. and Zhang, H.H. 2009. Principles and Theory for Data Mining and Machine Learning.

BIM 510 ADVANCED BIOINFORMATICS (2+1)

Objective: To equip with advances in Bioinformatics and Bioinformatic tools.

Theory

BLOCK I: Biological databases

Unit I: Genomic databases and analysis of high-throughput data sets

Genomic databases and analysis of high-throughput data sets, Analysis of DNA sequence, Sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods.

Unit II: Algorithms for biological data analysis

EM algorithm and other statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, ClustalW and others. Concepts in phylogeny. Gene prediction based on codons, Decision trees, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models.

BLOCK II: Protein expression and structure analysis

Unit I: Computational analysis of protein sequence

Computational analysis of protein sequence, structure and function. Modeling protein families. Expression profiling by microarray / gene chip, proteomics etc., Multiple alignment of protein sequences, Modeling and prediction of structure of proteins, Designer proteins, Drug designing. Markov chains (MC with no absorbing states; Higher order Markov dependence; patterns in sequences; Markov chain Monte Carlo - Hastings-Metropolis algorithm, Simulated Annealing, MC with absorbing States), Bayesian techniques and use of Gibbs Sampling, Advanced topics in design and analysis of DNA microarray experiments. Computationally intensive methods (Classical estimation methods, Bootstrap Estimation and Confidence Intervals, Hypothesis testing, Multiple Hypothesis testing).

Unit II: Phylogenetics and Prediction of protein structures

Evolutionary models (Models of Nucleotide substitution), Phylogenetic tree estimation (Distances: Tree reconstruction – Ultrametric and Neighbor-Joining cases, Surrogate distances, Tree reconstruction, Parsimony and Maximum Likelihood, Modeling, Estimation and Hypothesis Testing), Neural Networks (Universal Approximation Properties, Priors and Likelihoods, Learning Algorithms – Back propagation, Sequence encoding and output interpretation, Prediction of Protein Secondary Structure, Prediction of Signal Peptides and their

cleavage sites, Application for DNA and RNA Nucleotide Sequences), Analysis of SNPs and Haplotypes.

Practical

- Genomic databases and analysis of high-throughput data sets, BLAST and related sequence comparison methods.
- Statistical methods to discover common motifs in biosequences, Multiple alignment and database search using motif models, ClustalW, Classificatory analysis.
- Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models.
- Computational analysis of protein sequence, Expression profiling by microarray/gene chip, proteomics, Modelling and prediction of structure of proteins, Bayesian techniques and use of Gibbs Sampling.
- Analysis of DNA microarray experiments, Analysis of one DNA sequence.
- Analysis of multiple DNA or protein sequences, Computationally intensive methods, Multiple Hypothesis testing.
- Phylogenetic tree estimation, Analysis of SNPs and Haplotypes.

Reference

- HELDER, I. N., editor. Brisbane (AU): Bioinformatics Exon Publications; 2021 Mar 20.
- HUSI, H., editor. Brisbane (AU) : Computational Biology, Codon Publications; 2019. Nov. 21.

M.Sc. (Agri.) in Entomology

Course Code	Course Title	Credit Hours
ENT 501	Insect Morphology	3 (2+1)
ENT 502	Insect Anatomy and Physiology	3 (2+1)
ENT 503	Insect Taxonomy	3 (2+1)
ENT 504	Insect ecology	3 (2+1)
ENT 505	Biological Control of Insect Pests and Weeds	3 (2+1)
ENT 506	Toxicology of Insecticides	3 (2+1)
ENT 507	Host Plant Resistance	2 (1+1)
ENT 508	Concepts of Integrated Pest Management	2 (2+0)
ENT 509	Pests of Field Crops	3 (2+1)
ENT 510	Pests of Horticultural and Plantation Crops	3 (2+1)
ENT 511	Post-Harvest Entomology	2 (1+1)
ENT 512	Insect Vectors of Plant Pathogens	2 (1+1)
ENT 513	Principles of Acarology	2 (1+1)
ENT 514	Vertebrate Pest Management	2 (1+1)
ENT 515	Techniques in Plant Protection	1 (0+1)
ENT 516	Apiculture	3 (2+1)
ENT 517	Sericulture	3 (2+1)
ENT 518	Lac Culture	3 (2+1)
ENT 519	Molecular Approaches in Entomology	3 (2+1)
ENT 520	Plant Quarantine, Biosafety and Biosecurity	2 (2+0)
ENT 521	Edible and Therapeutic Insects	2 (1+1)
ENT 522	Medical and Veterinary Entomology	2 (1+1)
ENT 523	Forest Entomology	2 (1+1)
	Total	**57 (36+21)**
ENT 580	Qualifying	2 (0+2)
ENT 581	Seminar - I	1 (0+1)
ENT 582	Seminar - II	1 (0+1)
ENT 591	Research - I	13 (0+13)
ENT 592	Research - II	14 (0+14)

ENT 501 INSECT MORPHOLOGY (2+1)

Objective

To acquaint the students with the external morphology of the insect's body and the functioning of various body parts.

Theory

Block – 1: External and internal modifications in insects

Unit 1: External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites.

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications. Abdomen- Segmentation and appendages; genitalia and their modifications.

Block – 2: Insect sensory organs and their functions

Unit 1: Insect sense organs (mechano-, photo- and chemo-receptors); organogenesis at pupal stage; insect defence; chaetotaxy; morphological traits in relation to forensic entomology.

Block – 3 : Life history strategies in insects

Unit 1: Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi- metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including 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, Hymenoptera and Coleoptera using key.

References

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ENT 502 INSECT ANATOMY AND PHYSIOLOGY (2+1)

Objective

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

Theory

Block – 1: Integument and its role in insect biology

Unit –1: Scope and importance of insect physiology; physiology of integument, moulting, chemistry of cuticle, bio-synthesis of chitin; growth, hormonal control, metamorphosis and diapause; pheromone secretion, transmission, perception and reception.

Block–2 : Insect internal systems and their functions

Unit 1: Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretion (exocrine & endocrine glands) and nerve impulse transmission in insects.

Block–3: Insect nutrition physiology

Unit 1: Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; ar tificial diets. Thermodynamics.

Practical

Dissection of systems in insects; determination of chitin in insect cuticle; examination and count of insect haemocytes; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

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- GULLAN, P. J. AND CRANSTON, P. S., 2000, The Insects: An Outline of Entomology, 2ndEd. Blackwell Science, U.K.
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ENT 503 INSECT TAXONOMY (2+1)

Objective

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 in identifying the families of insects with an emphasis on the practical aspects.

Theory

Block – 1 : History and Insect classification

Unit – 1: History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy v/s homology, parallel v/s convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects- introduction to phylogeny of insects and Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systematics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labelling protocols and procedures.

Block–2: Insect orders and their morphological characteristics

Unit 1: Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

Block 3-: Insect orders and their economic importance

Unit 1: Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

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

References

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ENT 504 INSECT ECOLOGY (2+1)

Objective

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 fluctuation to biotic and /or abiotic causes.

Theory

Block – 1 Evolution, abundance and distribution of insets in relation to abiotic factors

Unit–1: 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.

Block- 2 Population ecology of insects

Unit–1: 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.

Block – 3 Role of abiotic factors in insect distribution and abundance

Unit- 1: 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.

Block – 4 Community ecology of insects

Unit–1: Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's d/w, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, 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.

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. Assessing and describing niche of some insects of a single guild.

Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

References

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ENT 505 BIOLOGICAL CONTROL OF INSECT PESTS AND WEEDS (2+1)

Objective

To train the students with 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

Block 1: Introduction and principles of biological control

Unit 1: History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsia and nematodes.

Block 2: Host - prey relationship and mass production of bioagents

Unit 1: Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

Unit 2: Mass production of quality bio-control agents- techniques, formulations, economics, field release/application and evaluation. Development of insectaries, their maintenance.

Block 3: Successful biological control projects and regulations for import of natural enemies

Unit 1: Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies-

Quarantine regulations, molecular approaches in biological control. Semio chemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, 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 insect pathogens. Quality control and registration standards for biocontrol agents.

References

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ENT 506 TOXICOLOGY OF INSECTICIDES (2+1)

Objective

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

Block–1: Insecticides and their classification

Unit 1: Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

Unit 2: 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 and other beneficial insects; general structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

Block–2: Assessment of insecticides

Unit 1: Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides- synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility and phytotoxicity. Insecticide bioassays- definition, objectives, methods.

Unit 2: Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

Block – 3: Registration and safe handling of insecticides

Unit 1: Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures and label claim;

Safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

Insecticide groups, formulations and mixtures; laboratory and field evaluation of bio-efficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity. Pesticide appliances. Working out doses and concentrations of pesticides.

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- CHATTOPADHYAY, S. B., 1985, Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.
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ENT 507 HOST PLANT RESISTANCE (1+1)

Objectives

Host plant resistance an effective weapon to minimize the losses due to insect pests. HPR will not only cause a major reduction in pesticide use and slowdown the rate of development of resistance to insecticides in insect populations, but also lead to increased activity of beneficial organisms and reduction in pesticide residues in food and food products.

Theory

Block–1: Plant resistance, classification and theories

Unit 1: History and importance of resistance; principles, classification, components, types and mechanisms of resistance.

Unit 2: Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

Block–2: Ecology and resistance mechanisms in host plants

Unit 1: Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance – systemic acquired and induced systemic resistance.

Unit 2: Factors affecting plant resistance including biotypes and measures to combat them.

Block – 3 Breeding for insect resistance and applications of biotechnology in host plant resistance

Unit 1: Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

Unit 2: Role of biotechnology in plant resistance to insects.

Practical

Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

References

- DHALIWAL, G. S. AND SINGH, R. (Eds)., 2004, Host Plant Resistance to Insects -Concepts and Applications. Panima Publ., New Delhi.
- MAXWELL, F. G. AND JENNINGS, P. R. (Eds)., 1980, Breeding Plants Resistant to Insects. John Wiley and Sons, New York.
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- SMITH, C. M., 2005, Plant Resistance to Arthropods - Molecular and Conventional Approaches.

ENT 508 CONCEPTS OF INTEGRATED PEST MANAGEMENT (2+0)

Objectives

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM. Train students in computation of ETL and implementing IPM programmes.

Theory

Block – 1: IPM and its components

Unit 1: History, origin, definition and evolution of various terminologies. Importance of host plant resistance, principles, classification, components, types and mechanisms of host plant resistance. National and international level crop protection organizations; insecticide regulatory bodies; label claim of pesticides – the pros and cons.

Unit 2: Concept and philosophy IPM, ecological principles, economic threshold concept and economic consideration. Insect- host plant relationships; theories and basis of host plant selection in phytophagous insects.

Block – 2: Tools of IPM and their application in pest management

Unit 1: Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.

Block – 3: Assessment of crop losses due to insect pests

Unit 1: 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; global and Indian scenario of crop losses. Computation of EIL and ETL; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India.

References

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ENT 509 PESTS OF FIELD CROPS (2+1)

Objective

To familiarize the students about nature of damage and seasonal incidence of pestiferous insects that cause loss to major field crops and their effective management by different methods.

Theory

Block – 1: Bionomics of insect &mite pests

Unit 1: Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.

Block – 2: Management of polyphagous pests and insect pests of cereals

Unit 1: Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars and non-insect pests (mites, birds, rodents, snails, slugs etc.). Insect pests of cereals (Paddy, Maize, Wheat and Bajra) and millets (Ragi and Jowar) and their management.

Block – 3: Management pests of pulses and oil seeds

Unit 1: Insect pests of pulses (Red gram, Chickpea, Black gram, Green gram, Lab-lab, and Cowpea), tobacco, oilseeds (Groundnut, Castor, Sunflower, safflower, Mustard and Soybean) and their management.

Block – 4: Management pests of fibre and forage crops

Unit 1: Insect pests of fibre crops (Cotton, Jute and Mesta), forage crops (Fodder sorghum,Lucerne, Pearl-millet), sugarcane and their management.

Practical

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

References

- DAVID, B. V. AND RAMAMURTHY, V. V., 2001, Elements of Economic Entomology. Popular Book Depot, Chennai.
- DHALIWAL, G. S., SINGH R AND CHHILLAR, B. S., 2006, Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
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- NAIR, MRGK., 1986, Insect and Mites of Crops in India. ICAR, New Delhi.
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• SAXENA, R. C. AND SRIVASTAVA, R. C., 2007, Entomology at a Glance. Agrotech Publ. Academy, Udaipur.

ENT 510 PESTS OF HORTICULTURAL AND PLANTATION CROPS (2+1)

Objective

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, their integrated management.

Theory

Block–1: Bionomics of insect &mite pests

Unit 1: Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.

Block – 2: Management of insect pests of fruit crops

Unit 1: Fruit Crops- mango, citrus, guava, banana, grapes, pomegranate, ber, papaya, sapota, jack, fig, apple and other temperate fruit like apple included and their management.

Block – 3: Management of insect pests of vegetable crops

Unit 1: Vegetable crops- brinjal, tomato, potato, okra, cole crops, gourds, French beans, chow-chow, radish, carrot, beetroot, gherkin, drumstick, leafy vegetables etc.

Block – 4: Management of insect pests of plantation crops, spices and condiments

Unit 1: Plantation crop-coconut, arecanut, cashew, coffee, tea, rubber, cocoa etc.,

Spices and Condiments- cardamom, pepper, chillies, turmeric, ginger, beetle vine etc.

Block – V: Management of insect pests of ornamental, medicinal & aromatic crops

Unit 1: Ornamental crops (Jasmine, Rose, Chrysanthemum, Gerbera, Marigold etc.,)

Medicinal and Aromaticplants (amla, ashwagandha, coleus (patharchur), kalihari / glory lily, isabgol, pippali (long pepper), safedmusli, senna, shatavari (Indian asperagus), Stevia.

Practical

Collection and identification of important pests and their natural enemies on different crops; study of life history of important insect pests and non-insect pests.

References

- ATWAL, A. S. AND DHALIWAL, G. S., 2002, Agricultural Pests of South Asia and their Management. Kalyani Publ., New Delhi.
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- VERMA, L. R., VERMA, A. K. AND GOUTHAM, D. C., 2004, Pest Management in Horticulture Crops: Principles and Practices. Asiatech Publ., New Delhi.

ENT 511 POST HARVEST ENTOMOLOGY (1+1)

Objective

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory

Block–1: History and concepts in storage entomology

Unit 1: Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses in toto vis-aÌ-vis total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.

Block–2: Insects and non-insect pests, storage structures in post-harvest entomology

Unit 1: Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

Block–3: Role of abiotic factors in storage of food grains and commodities

Unit 1: Ecology of insect pests of stored commodities/grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures *i.e.*, traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

Block – 4: Management of insects and non- insects pests of storage

Unit 1: Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control-

prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; integrated approaches to stored grain pest management.

Practical

Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them; detection of hidden insect infestation in stored food grains; estimation of uric acid content in infested produce; estimation of losses in stored food grains; determination of moisture content in stored food grains; familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques; treatment of packing materials and their effect on seed quality. Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, IGSMRI, Hapur etc. (only where logistically feasible).

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ENT 512 INSECT VECTORS OF PLANT PATHOGENS (1+1)

Objective

To teach the students about the different groups of insects that act as vectors of plant pathogens, vector-plant pathogen interaction, and management of vectors for controlling diseases.

Theory

Block–1: History, Characteristics and Feeding processes of important insect vectors

Unit 1: History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

Unit 2: Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

Block–2: Transmission of plant viruses and mycoplasma by sap feeding insects

Unit 1: Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

Unit 2: Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

Unit 3: Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies. Vector rearing and maintenance; estimating vector transmission efficiency, studying vector-virus host interaction.

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ENT 513 PRINCIPLES OF ACAROLOGY (1+1)

Objective

To acquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

Theory

Block–1: History and importance of mites and other soil arthropods

Unit 1: History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.

Block–2: Morphology and biology of major orders & families of mites and ticks

Unit 1: Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

Block–3: Economic importance of mites and their management

Unit 1: Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens *etc.* Culturing of phytophagous, parasitic and predatory mites. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.

Practical

Collection of mites from plants, soil and animals; extraction of mites from soil, plants and stored products; preparation of mounting media and slide mounts; external morphology of mites; identification of mites up to family level using keys; studying different rearing techniques for mites.

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ENT 514 VERTEBRATE PEST MANAGEMENT (1+1)

Objective

To impart knowledge on vertebrate pests like birds, rodents, mammals and others of different crops, their biology, damage they cause and management strategies.

Theory

Block–1: Introduction and biology of vertebrate pests

Unit 1: Introduction to vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals.

Block–2: Bio ecology and management of pestiferous birds

Unit 1: Bio-ecology of birds of agricultural importance, patterns of pest damage and assessment, roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.

Block–3: Bio ecology and management of pestiferous rodents

Unit 1: Bio-ecology of rodents of agricultural importance, patterns of pest damage and assessment, burrowing pattern and habitat of rodents; management of pestiferous rodents.

Block–4: Bio ecology and management of pestiferous higher vertebrates

Unit 1: Bio-ecology of higher vertebrates of agricultural importance, patterns of damage and assessment, their habitat; management of pestiferous vertebrates.

Block–5: Management of vertebrate pests in Agricultural eco system

Unit 1: Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods - Operational practices-baiting, equipments and educative programmes.

Practical

Identification of important rodents, birds and other vertebrate pests of agriculture, food preference and hoarding, social behaviour, damage assessment, field survey, population estimation, management strategies: preventive and curative methods.

References

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ENT 515 TECHNIQUES IN PLANT PROTECTION (0+1)

Objective

To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, etc.

Practical

Block–1: Spraying appliances and pesticide application

Unit 1: Pest control equipments, principles, operation, maintenance, selection, and application of pesticides; release of bio-control agents; seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water; application of drones in plant protection.

Block - 2 Different methods of pest management

Unit 1: Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers.

Unit 2: Uses of light, transmission and scanning electron microscopy.

Block–3: Isolation, characterisation of proteins and tissue culture and computer applications

Unit 1: Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE.

Unit 2: Use of tissue culture techniques in plant protection. Computer application for predicting/ forecasting pest attack and identification.

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ENT 516 APICULTURE (2+1)

Objective

To impart knowledge about the honey bees, and their behaviour and activities; bee husbandry, bee multiplication, bee enemies and diseases and their management; hive products, apitherapy; and managed bee pollination of crops.

Theory

Block–1: History and development of Apiculture in India

Unit 1: Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus Aphis and races; Morphology and anatomy of honey bee; Honey bee biology, ecology, adaptations; Honey bee behaviour – nest founding, comb construction, brood care, defence, other in-house and foraging activities; Bee pheromones; Honey bee communication.

Block–2: Commercial bee keeping

Unit 1: Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting – causes and management; Curbing drone rearing; Laying worker menace – causes, signs and management.

Block–3: Reproductive biology of bees

Unit 1: Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages

Block–4: Parasites and predators of Bees

Unit 1: Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptoms of damage, management tactics; Wax moths, wasps and ants - biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees

Block – 5: Honey and its value addition

Unit 1: Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and beeswax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.

Block–6: Pollination ecology

Unit 1: Non-Apis pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

Practical

Morphological characteristics of honey bee; mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees; recording of colony performance; seasonal bee husbandry practices; swarming, queenlessness, swarming, laying workers menaces, etc. & their remedies; innovative techniques in mass queen bee rearing; selection and breeding of honey bees; instrumental insemination; formulation of artificial diets and their feeding; production technologies for various hive products; bee enemies and diseases and their management; recording pollination efficiency; application of various models for determining pollination requirement of crop; developing a beekeeping project.

References

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ENT 517 SERICULTURE (2+1)

Objective

To familiarize the students with entrepreneurial opportunities in entomology, sericulture in particular, and providing information on silk worm rearing, production and management.

Theory

Block–1: History and importance of Sericulture in India

Unit 1: History of Sericulture, importance, organizations involved in sericulture activities, silkworm types, distribution, area and silk production.

Block–2: Mulberry cultivation and species of silkworm

Unit 1: Mulberry species, ecological requirements, cultivation, improved varieties, propagation methods, sapling production, planting and pruning techniques; pest and diseases, management strategies; intercropping, water and weed management. Food plants of eri silkworm, castor cultivation, intercultural operations, nutrient and water management; method of harvest; host plants of Tasar, nursery and cultivation, selection of seed, soaking and heap making, pruning techniques. Food plants of Muga silkworm, Som and Soalu propagation methods; nursery techniques; intercultural operations and weed management.

Block–3: Silkworm classification and bioeology

Unit 1: Silkworm origin – classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races – multivoltine and bivoltine races –cross breeds – bivoltine hybrids –Races and hybrids of mulberry, eri, tasar and muga silkworm- Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.

Block– 4: Rearing, pest and diseases of Silk worm

Unit 1: Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and

moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.

Block–5: Cocoon technology

Unit 1: Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.

Practical

Morphology of mulberry plants – Identification of popular mulberry genotypes – Nursery bed and main field preparation – planting methods – Identification of nutrient deficiency symptoms – Identification of weeds– pruning and harvesting methods – Identification of pests and diseases of mulberry–Terminalia arjuna, Terminalia tomentosa, Som and Soalu- Nursery and pruning techniques – Intercultural operations.

Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm egg production technology –Tasar, Eri and muga silkworms – rearing methods–pests and diseases of non-mulberry silkworms - Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.

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ENT 518 LAC CULTURE (2+1)

Objective

To familiarize the students with entrepreneurial opportunities in entomology with an emphasis on lac culture in particular. To provide information on lac insect rearing, production and management.

Theory

Block–1: Importance of lac in India

Unit 1: History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.

Block-2: Cultivation of lac in India

Unit 1: Steps and operation of lac production; lac host plant species, ecological requirements, their cultivation; seasons of host plants, harvest time of host plants, rearing seasons; grouping of host trees, pruning

methods, timing; lac host plant pests and diseases; management strategies.

Block–3: Biosystematics and biology of lac insect

Unit 1: Basic morphology and taxonomy of lac insect, strains of lac insect and their characteristics; composition of lac; biology of lac insect, species diversity and distribution

Block–4: Production technologies of lac

Unit 1: Introduction, lac insect-host plant interaction; selection of brood lac, local practices, improved alternatives, coupe system; propagation of lac insects: natural self inoculation, artificial inoculation; inoculation process and duration; removal of phunki, harvesting of lac, immature harvesting, mature harvesting and time of harvesting. Predators and parasitoids of lac insect, hyperparasites, diseases and their management.

Block–5: Host plants and value addition of lac

Unit 1: Lac production stages; factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method; technology of brood preserving. Host-specific technologies - cultivation on specific host plants; integration of lac cultivation with agro-forestry and horticulture; socio- economic potential of lac; export-import of lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.

Practical

Lac host cultivation and lac production practices; equipments for lac production; conventional and advanced methods; coupe system of lac production; cultivation of suitable host plants; pruning of host trees; herbarium of host plants; strains of lac insects; brood lac selection and treatment for pest management; slide preparation of adult and immature stages; inoculation of host tree; identification of natural enemies of lac insect and their management; molecular characterization of lac insect where possible; harvesting; process of manufacture of seed lac, shell lac from stick lac; grading of seed lac and shellac; marketing of lac products and by products.

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ENT 519 MOLECULAR APPROACHES IN ENTOMOLOGY (1+1)

Objective

To acquaint students the latest techniques used in molecular biology.

Theory

Block–1: Importance of molecular biology and DNA recombinant technology

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

Unit 2: DNA recombinant technology, identification of genes/ nucleotide sequences for traits of interest, techniques of interest in plants and microbes.

Block–2: Transgenics in Entomology

Unit 1: Molecular approaches in entomological research - peptides and neuropeptides, JH esterase, toxins and venoms, chitinase, Plant-derived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terepenes and terpenoids; genes of non-plant origin, *Bacillus thuringiensis* endotoxins, mode of action of cry genes, classification and properties, synthetic Bt toxin genes, Other toxin genes, transgenic plants for pest resistance.

Block–3: Genetic engineering of microbes and parasitoids

Unit 1: Genetically engineered microbes and parasitoids in biological control-Genetic engineering in baculoviruses and fungal bio control agents for greater efficacy against insect pests. Effects of transgenic plants on pest biology and development, resistance

management strategies in transgenic crops, molecular mechanism of insecticide resistance.

Block–4: Genetics based insect pest management

Unit 1: Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique. Methods and application of insect trangenesis, transgenics in silkworm and honeybees. Molecular tools for taxonomy and phylogeny of insect-pests, DNA-based diagnostics. Nano technology and its application.

Practical

Isolation of DNA/RNA; agarose gel electrophoresis of DNA, quantification of DNA by Nanopore / spectrophotometirc and agarose gel analysis, PCR amplification of mitochondrial cytochrome oxidase subunit I gene (cox1) and 16S r RNA gene, PCR machine applications, BLAST analysis and multiple sequence alignment of the sequence with sequences already available in Gen Bank.

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ENT 520 PLANT QUARANTINE, BIO-SAFETY AND BIO-SECURITY (2+0)

Objective

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. Also, to facilitate students to have a good understanding of the aspects of biosafety and biosecurity.

Theory

Block–1: Quarantine and legal management

Unit 1: 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.

Block–2: Plant protection organisation in India

Unit 1: Plant protection organization in India. Acts related to registration of pesticides and transgenics. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procedures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Block–3: Diagnostic techniques for pest and diseases

Unit 1: Identification of pest/disease free areas; contamination of food with toxicgens, 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.

Block–4: Concepts in biosecurity and biosafety

Unit 1: WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

References

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ENT 521 EDIBLE AND THERAPEUTIC INSECTS (1+1)

Objectives

To create awareness and acquaint students about the contribution that insects make to ecosystems, diets, food security and livelihoods in developed and developing countries.

Theory

Block–1: Introduction and importance of edible insects

Unit-1: Edible and therapeutic insects: the concept, definition, and importance.

Unit 2: History and origin of insects as food, feed and medication; important insect species and insect products consumed

Unit- 3: Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing.

Block–2: Conservation and management of edible insects

Unit 1: Nutritional composition and role insects in food security.

Block-3: Farming and processing of edible insects

Unit 1: Insect farming: the concept, definitions, and rearing techniques.

Unit 2: Processing edible insects for food and feed

Unit 3: Food safety and preservation, edible insects for livelihood security.

Practical

Survey and identification of edible and therapeutic insect species; collection and preservation of edible and therapeutic insect specimens; rearing techniques of edible insect species; harvesting techniques of edible insects from natural environment; analysis of proximate elemental composition, antioxidant and anti-nutritional properties and microbial aspects of preservation.

References

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ENT 522 MEDICAL AND VETERINARY ENTOMOLOGY (1+1)

Objective

To study the major insect, mite, and tick vectors of disease to man and animals. Students will learn to identify and understand the life cycles, morphology, and behaviour of mosquitoes, ticks, mites, lice, fleas, and other disease vectors.

Theory

Block–1: Medical and veterinary importance of insects

Unit 1: Introduction to medical, veterinary and forensic entomology;

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FSN 513 FOOD PRODUCT DEVELOPMENT (1+1)

Objective

To expose students to the basic principles of food product development, sensory properties, food packaging and labelling and their role in product development.

Theory

Block I: Development of product

Unit I: Formulation and evaluation

Basic Principles of food product development. Sensory properties of food and their role in product development. Formulation and evaluation of recipes at laboratory level. Bulk food preparation for food institutions and enterprises: servings, nutritive value and costing. Evaluation of food.

Unit II: Selection and training

Selection and training of judges, development of score cards and analysis of data.

Unit III: Data analysis

Consumer evaluation-development of scheduleand data analysis.

Block II: Packaging and labelling

Unit I: Food packaging

Packaging material, types for different products. Food labelling.

Unit II: Food safety

Food safety issues in product development, food quality regulations and standards, quality control and HACCP.

Unt III: Product development

Product formulation and development for general and therapeutic use.

Practical

1-3: Sensory evaluation methods, training of judges, score card preparation.

4-7: Selection and modification of food product to be developed. Formulation and standardization of products.

8:Objective and subjective evaluation of the products.

9:Evaluation of consumer acceptability.

10-12: Packaging and sale of products.

13-16: Preparation of video film for media.

References

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- HOWARD, R. MOSKOWITZ, SAGUY, I. S. AND STRAUS. T., New product Development, CRC Publication.
- MRIDULA PATIL, R. T., MANIKANTAN, M. R., Food Processing Technology Co-Product utilization and quality assurance. Satish serial publishing house.
- SUDEER, K. P. AND INDIRA, V. Entreprenuership development in food processing, New India publishing agency.

FSN 514 NUTRITION AND IMMUNITY (1+0)

Objective

To impart knowledge about role of macro and micronutrients and phytochemicals in improving immune systems and about nutrition and immunity in disease management.

Theory

Block I: Effect of nutrition on Immunity

Unit I: Basics of nutrition and immunity

Immunity: definition, history, classification, immunological responses, cell types involved. Mechanism of phagocytosis and antigen-antibody reactions. Regulation of immunity. Mucosal defense system-effect of nutrients.

Unit II: Malnutrition and immunity.

Effect of malnutrition on immunity. Carbohydrates and immune system. Fat and immune system- factors affecting acquired immunity. Protein and immune functions- effect of arginine, glutamine and Sulphur amino acids. Glutathione and immune system

Unit III: Protective nutrients and immunity

Role of vitamins in immune functions-effect of deficiency. Role of minerals-effect of deficiency and excess on immune cell functions.

Block II: Probiotics and antioxidants.

Unit I: Role of Probiotics and antioxidants on immunity.

Effect of Probiotics and antioxidants on immune function. Immunity against infection – role of immunization

References

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2. GERSHWIN, M. E., NESTEL, P. AND KEEN, C. L, 2004, *Handbook of Nutrition and Immunity*. Humana Press Inc. New York.
3. SHETTY, P. S., 2010, *Nutrition, Immunity and Infection*. CABI Publishers, Oxfordshire, UK.
4. CALDER, P. AND YAQOOB, P., 2013, *Diet, Immunity and Inflammation*. Wood head Publishing Ltd. Cambridge.
5. PAMMI, M.,VALLEJO, J. G. AND ABRAMS, S. A., 2016, *Nutrition-Infection Interactions and Impacts on Human Health*.

CRC Press, Boca Raton, Florida.

6. PHILIP, C. CALDER, ANIL, D. KULKARNI, 2017, *Nutrition, Immunity, and Infection.* CRC press, London

7. IVAN, M. ROITT. & PETER, J. DEVES., 2004, *Essential Immunology.* Black well Science Ltd.

FSN 515 FUNCTIONAL FOODS (0+1)

Objective

To expose students on different functional foods in daily dietary

Practical

1-2: Functional properties of food components in food systems with suitable applications.

3-4: Traditional Foods: Selection of a product and study of preparation variables.

5-6: Convenience Foods - Identification of technologies used in different groups of foods. Advances in product formulation and techniques. Use of unconventional cereals and pulses in products.

7: Biotechnology in food processing. Microwave technology

8-11: Nutraceuticals: Definition, need, importance, classification / types – sources – processing of nutraceutical products – role in health – therapeutic applications. Pharma Foods: Diabetic foods – confectioneries, sodium free, lactose free, phenylalanine free, fiber rich-nutritional implications.

12-14: Dietary supplements, fortification of nutrients in the processed foods, role in health. Nonnutritive sweeteners: Definition, need, importance, types, development of sugar free products, nutritional implication, current market trend, artificial sweeteners therapeutic applications.

M.Sc. (Agri.) in Genetics and Plant Breeding

Course Code	Course Title	Credit Hours
GPB 501	Principles of Genetics	3 (2+1)
GPB 502	Principles of Plant Breeding	3 (2+1)
GPB503	Fundamentals of Quantitative Genetics	3 (2+1)
GPB 504	Varietal Development and Maintenance Breeding	2 (1+1)
GPB 505	Principles of Cytogenetics	3 (2+1)
GPB 506	Molecular Breeding and Bioinformatics	3 (2+1)
GPB 507	Breeding for Quality and Special Traits	3 (2+1)
GPB 508	Mutagenesis and Mutation breeding	3 (2+1)
GPB 509	Hybrid Breeding	3 (2+1)
GPB 510	Seed Production and Certification	2 (1+1)
GPB 511	Crop Breeding, I (*Kharif* Crops)	3 (2+1)
GPB 512	Crop Breeding II (*Rabi* Crops)	3 (2+1)
GPB 513	Breeding Vegetable Crops	3 (2+1)
GPB 514	Breeding Fruit Crops	3 (2+1)
GPB 515	Breeding Ornamental Crops	3 (2+1)
GPB 516	Breeding for Stress Resistance and Climate Change	3 (2+1)
GPB 517	Germplasm Characterization and Evaluation	2 (1+1)
GPB 518	Genetic Enhancement in PGR utilization	2 (1+1)
	Total	**50 (32+18)**
GPB 580	Qualifying	2 (0+2)
GPB 581	Seminar - I	1 (0+1)
GPB 582	Seminar - II	1 (0+1)
GPB 591	Research - I	13 (0+13)
GPB 592	Research - II	14 (0+14)

GPB 501 PRINCIPLES OF GENETICS 3 (2+1)

Theory

Block I Classical/Mendelian Genetics

Unit I: Beginning of genetics**,** early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Multiple alleles, Epistatic and non-epistatic gene interactions

Unit II: Chromosomal theory of inheritance, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits

Unit III: Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes,

Unit IV: Extra chromosomal inheritance, genetics of mitochondria and chloroplasts, Haploid Genetics and Genetics of DNA Markers.

Block II Population Genetics

Unit I: Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

Block III: Cell and Molecular Genetics

Unit I: Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters;

Unit II: Transcription, Translation, Genetic code; Protein biosynthesis, Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression;

Unit III: Synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Concepts of Eugenics, Epigenetics, Genetic disorders.

Practical's

Laboratory exercises in probability and chi-square; Demonstration of genetic principles (Monohybrid ratios, Dihybrid ratios) using

laboratory organisms; Chromosome mapping using three-point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification; Electrophoresis: basic principles and running of amplified DNA;

References

- DANIEL LH AND MARYELLEN R. 2011. *Genetics: "Analysis of Genes and Genomes"*.
- KLUG WS AND CUMMINGS MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition
- PETER SNUSTAD & MICHAEL J. SIMMONDS, 2017, Principles of Genetics, John Wiley & Sons.
- ROBERT H TAMARIN, 2017, Principles of Genetics, Tata McGraw-Hill, 609 Pp.
- STANSFIELD WD.1991. *Genetics.*Schaum Outline Series Mc Graw Hill
- STRICKBERGER MW. 2005. *Genetics* (*III Ed*). Prentice Hall, New Delhi, India; 3rd ed., 2015.

GPB 502 PRINCIPLES OF PLANT BREEDING 3 (2+1)

Objective of the course

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

Theory

Block I: History, objectives and accomplishments of plant breeding, genetic resources and pre-breeding

Unit I: History, objectives and accomplishments of plant breeding; international agriculture research centers engaged in plant breeding; centers of origin and diversity of crop plants, plant genetic resources (PGR) and their significance in plant breeding; pre-breeding - plant introduction, germplasm conversion, wide hybridization, etc.

Block II: Genetic basis of plant breeding

Unit I: Modes of reproduction and cultivar options; determination of modes of reproduction; consequences of selfing and crossing; genetic structure of different types of cultivars; quantitative inheritance, nature of variability, components of variation; heritability and genetic advance; general and specific combining ability; modes of gene actions (additive, dominance and epistasis) and their implications in plant breeding; probability of fixation of desirable genotypes and identifying transgressive genotypes.

Block III: Selection in plant breeding

Unit I: Breeding methods in self pollinated crops; pure line theory; selection methods in genetically variable natural populations - pure line and mass selection methods; selection of parents to develop breeding populations (segregating populations); selection among breeding populations; selection methods within selected breeding populations - pedigree, bulk, single seed descent selections; backcross breeding and its applications - multiline breeding, concepts of marker-assisted selection; improvement of source breeding populations in self – pollinated crops with special reference to diallel selective mating for enhancing selection gain.

Unit II: Breeding methods in cross pollinated crops; population breeding: mass selection and ear-to-row methods; S_1 and S_2 progeny testing, progeny selection schemes, rationale of recurrent selection (RS), RS schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding, genetical and physiological basis of heterosis and inbreeding; concept of heterotic groups and heterotic patterns; use of synthetics and composites and their improved versions (by RS schemes) for developing inbred lines for use in developing hybrids; recycling inbred parental lines of elite hybrids; selection of combinations of parents and testers for selecting inbred lines from breeding populations for use in hybrid cultivar development; methods of shortening breeding cycle (double haploid and rapid generation advancement) for developing inbred lines for use in hybrid

cultivar development; approaches for improvement of inbred lines of elite hybrids, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds; pollination control systems (self-incompatibility, male sterility and apomixes) in crop plants and their commercial exploitation.

Unit III: Clonal selection in asexually propagated crops; objectives of breeding cultivars for use as scion; objectives of breeding cultivars for use as root stock

Block IV: Special breeding techniques

Unit I: Mutation breeding - exploitation of natural and induced mutation-generated variability, polyploidy breeding – phenotypic effects of polyploidy; exploitation of natural and induced polyploidy-generated variability; participatory varietal selection and plant breeding

Block IV: Post-plant breeding

Unit I: Cultivar testing, genotype × environment interaction (GEI) - types of GEI (crossover and non-crossover), detection, quantification and approaches to exploit GEI in plant breeding; release and notification, maintenance breeding, plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

- Floral biology in self- and cross-pollinated species; selfing and crossing techniques
- Analysis of variance (ANOVA) - detection and quantification of variability attributable to different sources
- Estimation of heritability, and general and specific combining ability and prediction of genetic advance
- Prediction of *per se* and test cross performances of inbred lines based on *per se* mid parental and test cross performance
- Theoretical identification of best breeding population (F_2/ backcross) to be used to develop inbred lines for use as pure-line cultivar or in F_1 hybrid cultivar development

- Theoretical demonstration of the effect of independent assortment and linkage of genes on probability of fixation of combination of desirable alleles; prediction of performance of three-way and double cross hybrids.

References

- ALLARD RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
- SIMMONDS NW.1990. *Principles of Crop Improvement*. English Language Book Society.
- SHARMA JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
- CHAHAL GS AND GOSSAL, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional Approaches.* Narosa Publishing House.
- ROY D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House.
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- GEORGE ACCQUAAH. 2020. *Principles of Plant Genetics and Breeding*. Third Edition, Wiley-Blackwell, USA.

GPB 503 FUNDAMENTALS OF QUANTITATIVE GENETICS 3 (2+1)

Objective of the course

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

Theory

Block I: History and conceptual framework of classical quantitative genetics

Unit I: Introduction and historical background of quantitative genetics, multiple factor hypothesis, qualitative and quantitative traits, modeling quantitative traits' variation using first degree statistics (such as mean and range), and second degree statistics (such as standard deviation, variance, covariance); scaling and joint scaling tests for examining the adequacy of additive-dominance model; concepts of average effect of alleles, average effect of allelic substitution and breeding value; epistasis and parameters specifying epistasis at first-degree statistics level; perfect-fit solution to detect and testing the significance of parameters specifying epistasis; components of phenotypic and genotypic variation; estimation of phenotypic and genotypic variation using basic ANOVA (based on expected variance components) and using variances of segregating and non-segregating basic generations; concept of random and fixed effect models; methods of estimation of heritability-parent-progeny regression, half-sib covariance and full-sib covariance analysis.

Unit II: Concept of combining ability; types of combining ability at first and second degree statistics levels; estimation of gca and sca effects and their variances using mating designs such as diallel, line × tester; G × E interaction – types and their detection and exploitation in plant breeding; concepts of adaptability and stability; basic models and methods for stability analysis and interpretation; bi-plot analysis; designs for plant breeding experiments- principles and applications.

Block II: Quantitative genetic basis of selection

Unit I: Concept of selection, direct and indirect selection; correlated response to selection.

Unit II: Association analysis - genotype and phenotypic correlation, path analysis; methods of groping genotypes - principal component analysis and Toacher's method, genetic divergence analysis based on D^2 statistic.

Block III: Marker-assisted quantitative genetics

Unit I: DNA markers - types and inheritance; concept of linkage map and its construction; principles of QTL mapping; mapping populations, and approaches and analytical tools for QTL mapping; marker assisted selection and factors influencing the MAS.

Practical

- Analysis and interpretation of variability parameters.
- Clustering and interpretation of D^2 analysis
- Genotypic and phenotypic correlation analysis and interpretation
- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation
- A, B, C and D scaling tests, estimation of genetic components of generation means, joint scaling tests; estimation of components of variance using basic generations data.
- Line × Tester and diallel analysis and interpretation, Use of computer packages for line × tester and diallel analysis.
- G×E interaction and stability analysis.
- Single marker and marker-regression approaches for QTL detection.

References

- MATHER K AND JINKS JL.1982. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.
- WEIR DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.

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- SINGH RK AND CHAUDHARY BD. 1987. *Biometrical Methods in Quantitative Genetic* analysis. Kalyani Publishers, New Delhi.
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- FALCONER DS AND MACKAY J. 1998. *Introduction to Quantitative Genetics* (3rd Ed.). Longman, London.
- ROY D. 2000. *Plant Breeding: Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.
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- REX BERNARDO. 2020. *Breeding for Quantitative Traits in Plants.* Third edition, Stemma Press, Woodbury, Minnesota, USA
- GEORGE ACCQUAAH. 2020. *Principles of Plant Genetics and Breeding*. Third Edition, Wiley-Blackwell, USA.

GPB 504 VARIETAL DEVELOPMENT AND MAINTENANCE BREEDING 2(1+1)

Objectives

It is an indispensable course which apprise the students about various practices and procedures in the development of a variety and steps to maintain the purity of varieties/ hybrids. Further, it provides basics of nucleus and breeder seed production techniques.

Aim of the course

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

Unit I: Variety Development systems and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

Unit II: DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.

Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified.

Unit IV: Quality seed production technology of self and cross-pollinated crop varieties, viz., cereals and millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi, etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

Unit V: Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

Practical

a. Identification of suitable areas/ locations for seed production;

b. Ear-to-row method and nucleus seed production;

c. Main characteristics of released and notified varieties, hybrids and parental lines;

d. PGMS and TGMS;

e. Identification of important weeds/ objectionable weeds;

f. Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops;

g. Hybrid seed production technology of important crops;

h. DUS testing and descriptors in major crops;

i. Variety release proposal formats in different crops.

References

- AGARWAL RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.
- KELLY AF. 1988. *Seed Production of Agricultural Crops*. Longman.
- MCDONALD MB JR AND COPELAND LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
- POEHLMAN JM AND BORTHAKUR D. 1969. *Breeding Asian Field Crops*. Oxford & IBH.
- SINGH BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani. 2015.
- THOMPSON JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.

GPB 505 PRINCIPLES OF CYTOGENETICS 3 (2+1)

Objective of the Course

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

Theory:

Block 1: Chromosome: its parts, functions and types

Unit I: Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes. Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -*In situ* hybridization and various applications.

Block 2: Chromosomal variations and their inheritance

Unit I: Structural and numerical variations of chromosomes and their implications; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Inter-varietal chromosome substitutions.

Block 3: Polyploidy and its application in plant breeding

Unit I: Fertilization barriers in crop plants at pre- and postfertilization levels; *In-vitro* techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid vs allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixes.

Unit II: Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, Triticale, Brassica, and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

Unit III: Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

- Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning, etc.;
- Microscopy: various types of microscopes;

- Preparing specimen for observation;
- Fixative preparation and fixing specimen for light microscopy studies in cereals;
- Studies on mitosis and meiosis in crop plants;
- Using micrometres and studying the pollen grain size in various crops.

References

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- DARLINGTON CD AND LA COUR LF. 1969. The Handling of Chromosomes. George Allen & Unwin Ltd.
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GPB 506 MOLECULAR BREEDING AND BIOINFORMATICS 3 (2+1)

Objective of the course

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

Theory

Block I: Markers: types, genetics/inheritance and their application in plant breeding

Unit I: Types of markers - morphological, biochemical and DNA-based markers and importance in plant breeding; concept, working principle and role of DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.,) in plant breeding

Unit II: Concept of linkage, concepts of DNA-based linkage map construction, relevance and use of mapping functions (Haldane and Kosambi) in map construction; tagging and mapping genomic regions/ quantitative traits loci (QTL): mapping populations (F_2s, backcrosses, RILs, NILs and DH); Approaches (Single marker, two markers and multiple markers) and analytical (statistical) tools (ANOVA, T test, F test and Regression) for mapping QTL controlling agronomicaly important traits.

Marker-assisted backcross breeding for introgression/pyramiding genomic regions controlling qualitative and quantitative traits; concept of EDVs. Concepts of gene editing and their application in plant breeding

Block II: Concept of bioinformatics and its application in plant breeding

Unit I: Methods to use genomic tools such as markers and candidate genes in breeding crops where such tools not available; Concept of allele mining, comparative genomics;

Introduction to bioinformatics; bioinformatics tools, biological data bases (primary and secondary), concepts of DNA marker primers, SSR and SNP markers' primer designing and their *in silico* validation; implications in plant breeding.

Block II: Breeding by design

Unit I: Concepts of recombinant DNA technology, physical and vector-mediated gene transfer, selectable and scorable markers; transgenes, transformation, and clean transformation techniques, Examples of production of transgenic plants in various field crops; cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc., and their commercial releases; molecular farming; application of tissue culture in developing transgenic crop cultivars; concepts of gene editing and its application in plant breeding. International and national (Indian) bio-safety ethical, legal and social issues/ regulations and intellectual property rights related to research on transgenic and gene edited crop cultivar development and their and commercial release.

Practical

- Estimation of linkage between pairs of markers; Linkage map construction
- Hands on experience on locus ordering protocols using numerical examples
- Conversion of non-additive recombination fractions to additive map distances using Haldane and Kosambi mapping functions with numerical examples
- Familiarity with the use of BLAST and Clustal W tools for DNA sequence analysis
- Hands on experience on SSR and SNP marker primer designing and their *in silico* vrediction of genes and their function.

References

- HACKETT PB, FUCHS JA AND MESSING JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.

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GPB 507 BREEDING FOR QUALITY AND SPECIAL TRAITS 3 (2+1)

Objective of the Course

To provide insight into recent advances in improvement of quality traits in cereals, millets, legumes, oilseeds, forage and industrial crops using conventional and modern biotechnological approaches.

Theory

Block 1: Importance of nutrition in human beings

Unit I: Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement

Block 2: Breeding for Nutritional Quality Improvements in Field Crops

Unit I: Breeding for grain quality parameters in rice and its analysis; Golden rice and aromatic rice: Breeding strategies, achievements and application in Indian context; Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

Unit II: Breeding for quality improvement in Sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits, brown midrib trait; Genetic resource management for sustaining nutritive quality in crops.

Block 3: Breeding for nutritional quality improvements in pulses, oilseeds and commercial crops

Unit I: Breeding for quality improvement in pulses – Chickpea, Pigeonpea, green gram and black gram cooking quality; Breeding for quality in oilseeds - groundnut, mustard, soybean, sesame, sunflower and minor oilseeds; Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality

improvement in cotton. Breeding for quality improvement in Sugarcane, potato.

Block 4: Genomics assisted breeding for nutritional quality

Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Nutritional genomics. Concept and use of gene editing in quality improvement

Practical

- Grain quality evaluation in rice;
- Quality analysis in millets;
- Estimation of anti-nutritional factors in different varieties/ hybrids: A comparison;
- Quality parameters evaluation in wheat, pulses and oilseeds;
- Evaluation of quality parameters in cotton, sugarcane and potato;
- Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures;
- Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

References

- CHAHAL GS AND SS GHOSAL. 2002. Principles and procedures of plant breeding - Biotechnological and Conventional approaches, Narosa Publications
- CHOPRA VL.1997. Plant Breeding. Oxford & IBH. 2018.
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GPB 508 MUTAGENESIS AND MUTATION BREEDING 3 (2+1)

Objective of the course

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

ii. To learn about mutation, various methods of inducing mutations and their utilization in plant breeding.

Theory

Block : 1 Mutation Classification and functionality

Unit I: Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations; Detection of mutations. Paramutations in crops plants.

Unit II: Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations. Effect of mutations on DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume.

Unit III: Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation – direct and indirect action, comparative evaluation of physical and chemical mutagens.

Block: 2 : Application of Mutation in Crop Improvement

Unit I: Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M_2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

Unit II: Use of mutagens in creating oligogenic and polygenic variations – Case studies; *In-vitro* mutagenesis – Callus and pollen irradiation; Handling of segregating M_2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

Practical

- Precautions on handling of mutagens; Studies of different mutagenic agents:Physical mutagens and Chemical mutagens;
- Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope 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;
- Study of M_2 generation – Parameters;

- Mutation breeding in cereals and pulses-achievements made and an analysis;
- Mutation breeding in oilseeds and cotton- achievements and opportunities;
- Mutation breeding in forage crops and vegetatively propagated crops;
- Procedure for detection of mutations for polygenic traits in M_2 and M_3 generations. parameters evaluation.

Suggested Reading

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- SINGH BD. 2003. *Genetics*. Kalyani Publishers, New Delhi. Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

GPB 509 HYBRID BREEDING 3(2+1)

Theory

Unit I: Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical and population genetic basis of heterosis.

Unit II: Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F_2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, their improvement for increasing heterosis.

Unit III: Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self-pollinated, cross pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

Unit IV: Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid; Organellar heterosis and complementation.

Unit V: Hybrid breeding in rice, cotton, maize, pearl millet, sorghum and rapeseed- mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

Practical

- Characterization of male sterile lines using morphological descriptors;
- Restorer line identification and diversification of male sterile sources;
- Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them;
- Diversification and restoration;

- Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeon pea;
- Understanding the difficulties in breeding apomicts;
- Estimation of heterotic parameters in self, cross and asexually propagated crops;
- Estimation from the various models for heterosis parameters;
- Hybrid seed production in field crops—an account on the released hybrids, their potential, problems and ways of overcoming it;
- Hybrid breeding at National and International level, opportunities ahead.

References

- AGARWAL RL. 1998. *Fundamental of Plant Breeding and hybrid Seed Production*. SciencePublisher London.
- AKIN E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.
- BEN HL. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.
- CHAL GS AND GOSSAL SS. 2002. *Principles and procedures of Plant Breeding, Biotechnology andConvetional Approaches*. Narosa Publishing House. New Delhi.
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- SRIVASTAVA S AND TYAGI R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.
- VIRMANI SS. 1994. *Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics"*, Springer-Verlag.

GPB 510 SEED PRODUCTION AND CERTIFICATION 2(1+1)

Objectives

Seed is the essence of life. Its improvement, production and maintenance is an essential feature of any variety. Seed chain concept is highly relevant in commercial promotion of new varieties whereas process of certification is mandatory for quality assurance of seed.

Aim of the course

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

Unit I: Importance of seed as basic input in agriculture; Seed quality concept and importance; Generation system of seed multiplication - Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.

Unit II: Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production

in self- and cross-pollinated crops; Hybrid seed production - system and techniques involved in Seed village concept; Organic seed production and certification.

Unit III: Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- and cross-pollinated cereals and millets.

Unit IV: Floral structure, pollination mechanism and methods and techniques of seed production in major pulses and oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor and Sunflower.

Unit V: Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops.

Unit VI: Seed certification - history, concept, objectives;Central seed certification board Seed certification agency/ organization and staff requirement; Legal status - Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

Practical

- Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony;
- Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination;
- Pollen collection and storage methods, pollen viability and stigma receptivity;
- Pre-harvest sanitation, maturity symptoms, harvesting techniques;
- Visits to seed production plots - visit to seed industries;

- Planning for seed production: cost benefit ratio, seed multiplication ratio and seed replacement rate;
- General procedure of seed certification, identification of weed and other crop seeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement;
- Specifications for tags and labels to be used for certification purpose.

References

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GPB 511 CROP BREEDING I (*KHARIF* CROPS) 3 (2+1)

Objectives

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major *Kharif* field crops.

Aim of the course

To provide insight into recent advances in improvement of kharif cereals, legumes, oilseeds, fibre, sugarcane and vegetative propagated crops using conventional and modern biotechnological approaches.

Theory

Unit I

Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics –biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding.

Maize: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, releasedvarieties, examples of MAS used for improvement- QPM and Bt maize – strategies and implications.

Small millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc.

Unit II

Pigeon pea: evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding

objectives: yield, quality characters, biotic and abiotic stress resistance, etc.*;* Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes.

Groundnut: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Urdbean, mungbean, cowpea,: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Soybean: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. **Castor and Sesame**: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement; Hybrid breeding in castor – opportunities, constraints and achievements.

Unit IV

Cotton: Origin, evolution, mode of reproduction, chromosome number; Genetics – biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton.

Jute: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit V

Sugarcane: Evolution and distribution of species and forms, wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance, etc.

Forage crops: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance, etc. **Seed spices**: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Practicals

Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton;

- Study of range of variation for yield and yield components;

- Study of segregating populations in cereal, pulses and oilseed crops;
- Learning on the crosses between different species; attempting crosses between black gram and green gram;
- Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton;
- Visit to Cotton Technology Laboratory and Spinning Mills;
- Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval;
- Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability;
- Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes;
- Visit to animal feed producing factories;
- Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.
- Assignments, quiz
- Group tasks, student's presentations.

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GPB 512 CROP BREEDING-II (*RABI* CROPS) 3(2+1)

Objectives

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major Rabi field crops.

Aim of the course

To provide insight into recent advances in improvement of *Rabi* cereals, legumes, oilseeds, fibre and vegetative propagated crops using conventional and modern biotechnological approaches

Theory

Unit I

Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Oats: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Barley: Origin, evolution, center of origin, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Unit II

Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Lentil, field pea, Rajma, Horse gram: Origin, evolution, mode of reproduction, chromosome number; Genetics. cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Rapeseed and Mustard: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives; yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality.

Sunflower, Safflower: Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit IV

Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number;

Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V

Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, scope of heterosis breeding, released varieties, examples of MAS used for crop improvement.

Practical

- Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea, rajma, rapeseed mustard, sunflower;
- Study of range of variation for yield and yield components;
- Study of segregating populations in cereal, pulses and oilseed crops;
- Use of descriptors for cataloguing; Learning on the crosses between different species;
- Trait based screening for stress resistance;
- Learning on the Standard Evaluation System (SES) and descriptors;
- Use of software for database management and retrieval.

References

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GPB 513 BREEDING VEGETABLE CROPS 3(2+1)

Objectives

This course enables the students to learn about breeding objectives, methodologies and genetics involved for the improvement of major vegetable crops.

Aim of the course

To educate about principles and practices adopted for breeding of vegetable crops.

Theory

Unit I: Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II: Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

Unit III: Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper

Unit IV: Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol. Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V: Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

Practical

- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
- Hybridization and handling segregating generations;
- Induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops;
- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops;
- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
- Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

References

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GPB 514 BREEDING FRUIT CROPS 3 (2+1)

Objectives

This course is aimed to educate the students about the breeding strategies and avenues in Fruit crops.

Aim of the course

To educate students about principles and practices adopted for breeding of fruit crops.

Theory

Unit I: Fruit crop breeding: History, importance of fruit breeding, centers of diversity, distribution, domestication and adaptation of commercially important fruits.

Unit II: Issues in fruit crop breeding – heterozygosity, polyploidy, polyembryony, parthenocarpy and seed lessness, incompatibility and sterility systems.

Unit III: Apomixis - merits and demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.

Unit IV: Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate, Pineapple and Guava, Apple and other Rosaceous crops andregion specific fruit crops.

Practical

- Germplasm documentation;
- Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops;
- Pollen germination to study time of anthesis and stigma receptivity;

- Hybridization technique in important fruit crops, hybrid seed collection and raising;
- Colchicine treatment for induction of polyploidy;
- Exposure to resistance breeding and screening techniques;
- Mutation breeding practices raising and evaluation of segregating populations;
- Use of mutagens to induce mutations and polyploidy;
- Visit to Biotechnology Lab and study of *in-vitro* breeding techniques.

References

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GPB 515 BREEDING ORNAMENTAL CROPS 3(2+1)

Objectives

The course will impart knowledge to student about breeding of Ornamental Crops through conventional and biotechnological interventions.

Aim of the course

To educate about principles and practices adopted for breeding of ornamental crops.

Theory

Unit I: History of improvement of ornamental plants; Centre of origin of ornamental crop; Objectives and techniques in ornamental plant breeding.

Unit II: Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, *Chrysanthemum*, Tuberose, *Gerbera*, *Gladiolus*, *Dahlia*, *Lilium*, *Gaillardia*, *Petunia*, *Bouganvillea*, Pansy, Marigold, *Geranium*, *Antirrhinum*, China aster, Orchids, *Carnation*, *Hibiscus*, etc.

Unit III: Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of F_1 hybrids and utilization of male sterility.

Unit IV: Production of open pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

Practical

- Study of floral biology and pollination in important species and cultivars of ornamental crops;
- Techniques of inducing polyploidy and mutation;
- Production of pure and hybrid seed;
- Methods of breeding suited to seed propagated plants;
- Polyploidy and mutations to evolve new varieties;
- Breeding methods for biotic and abiotic stresses;

- Visit to research institutes involved in ornamental crop breeding.

References

- ALEXANDER V. 2002. *Breeding for ornamentals: Classical and Molecular Approaches*. Kluwer Academic Publishers, London.
- ALLARD RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons. INC. New York.
- BHATTACHARJEE SK AND DE LC. 2003. *Advanced Commercial Floriculture* Vol. 1. Aavishkar Publishers & Distributors, Jaipur.
- BOSE TK AND YADAV LP. 2003. *Commercial Flowers*. Naya Prokash Publishers, Kolkata.
- CHADHA KL AND BHATTACHARJEE SK. *Advances in Horticulture* Vol. 12, Malhotra Publishing House, New Delhi.
- Mc Donald MB and Kwong FY. 2005. *Flower Seeds Biology and Technology*, CABI Publishing, Oxfordshire, UK.
- WATTS L.1980. *Flower and Vegetable Plant Breeding*. Grower Books

GPB 516 BREEDING FOR STRESS RESISTANCE AND CLIMATE CHANGE 3 (2+1)

Objective of the Course

To appraise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress tolerant varieties.

Theory

Block 1: Major biotic and abiotic stresses in crops

Unit I: Concept and impact of climatic change; Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops.

Block 2: Mechanism of plant disease resistance

Unit I: Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses

to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

Block 3: Conventional breeding for resistance to biotic and abiotic stresses

Unit I: Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; 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 developing breeding methodologies.

Block 4: Genomics enabled breeding for resistance to biotic and abiotic stresses

Unit I: Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/ freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.

Unit II: Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

Practical

- Symptoms and data recording; use of MAS procedures;
- Evaluating the available populations like RIL, NIL, etc. for pest resistance;
- Use of standard MAS procedures.
- Breeding for herbicide resistance;
- Screening crops for drought and flood resistance; factors to be considered and breeding strategies;
- Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies;
- Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

References

- BLUM A. 1988. Plant Breeding for Stress Environments. CRC Press.
- CHRISTIANSEN MN AND LEWIS CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International.
- FRITZ RS AND SIMMS EL. (Eds.). 1992. Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics. The University of Chicago Press.
- LI PH AND SAKAI A. 1987. Plant Cold Hardiness. Liss, New York Springer
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- SAKAI A AND LARCHER W. 1987. Frost Survival in Plants. Springer-Verlag.
- SINGH BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi
- TURNER NC AND KRAMER PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons.
- VAN DER PLANK JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

GPB 517 GERMPLASM CHARACTERIZATION AND EVALUATION 2(1+1)

Objective of the course

i. To impart the knowledge about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses.

ii. To learn about germplasm characterization, evaluation and documentation of information. Exposure to development of web based tools for systematic description for efficient use of germplasm.

Theory

Block : 1 Structure of Genetic Diversity and Characterization

Unit I: Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II: Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Unit II: Waste water treatment

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc*); anaerobic processes: digestion, filtration, etc.bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

References

- EVANS, G. M. AND FURLONG, J. C., 2010, Environmental Biotechnology: Theory and Application. 2nd edition, Wiley-Blackwell.
- JORDENING, H. J. AND WINTER, J., 2006, Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

MBB 516 BIO-ENTREPRENEURSHIP (1+0)

Objective

- The objective of this course is to teach students about fundamentals of entrepreneurship, launching a venture or a start up in biotechnology-based theme.

Theory

Block 1: Scope and Importance of Bio-entrepreneurship

Unit I: Overview of bio-industries and entrepreneurship development programs

Scope in biotechnology; types of bio-industries – bio-pharma, bio-agri, bio-services and bio-industrial; Importance of entrepreneurship; introduction to bioentrepreneurship – biotechnology in a global scale; – skills for successful entrepreneur–creativity, leadership, managerial, team building, decision making; opportunities for bio-entrepreneurship-entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India).

Unit II: Business development and SWOT analysis

Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/ support from various agencies; statutory and legal requirements for starting a company/ venture.

Block II: Incubation and Market linkages

Unit I: Incubation and technology transfer

Knowledge centers e.g., in Universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer.

Unit II: Market study and analysis

Entry and exit strategy; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for 'virtual startup company'. Pricing strategy.

References

- ADAMS, D. J. AND SPARROW, J. C., 2008, Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
- SHIMASAKI, C. D., 2014, Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
- ONETTI, A. AND ZUCCHELLA, A., 2014, Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
- JORDAN, J. F., 2014, Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
- Desai, V., 2009, The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

MBB 517 STRESS BIOLOGY AND GENOMICS (2+0)

Objective

To provide advanced knowledge on genomics with reference to abiotic stress tolerance and biotic stress resistance in plants tolerance**.**

Theory

Block 1: Stress Biology and Stress response

Unit I: Kinds of stresses and adaptation strategies

Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress – Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.

Unit II: Drought stress

Strategies to manipulate drought tolerance – Osmotic adjustment and Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism - ABA signaling; signaling components – transcription factors. Water logging stress – effects on plant growth and metabolism; adaptation to water logging,tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance.

Unit III: Salinity and heavy metal stress

Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis,Strategies to improve salinity tolerance in plants. Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes – High & Low temperature tolerance mechanisms - molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation -plastid

development. Characters of heliophytes and sciophytes – solar tracking – sieve effect and light channeling. Heavy metal stress – Al and Cd stress - effects on plant growth and development, Strategies to overcome heavy metal stress Nutrient stress-effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects.

Block 2 : Advanced techniques for stress tolerance

Unit I: Genomics and transgenic approaches for stress management

Transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Genomics; transcriptomes, small RNAs and epigenomes; functional genomics;

Unit II: Bioinformatics for stress management

Bioinformatics approaches to determine gene function and network in model plants under stress.

Reference

- BUCHANAN, B. B., GRUISSEM, W. AND JONES, R., 2015, Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley and Blackwell Publications.
- SARWAT, M., AHMAD, A., ABDIN, M. Z., 2013, Stress Signaling in Plants: Genomics and Proteomics Perspective, Volume 1, Springer.
- HERIBERT HIRT., 2010, Plant Stress Biology: From Genomics to Systems Biology, John Wiley.
- PANDEY, G. K., 2015, Elucidation of Abiotic Stress Signaling in Plants, Stringer.

MBB 518 GENE REGULATION (2+0)

Objective

- To understand the basics of gene regulation including a wide range of mechanisms that are used by organisms to increase or decrease the production of specific gene products in terms of time, space, conditions or their combinations.

Theory

Block I: Transcriptional regulation and regulatory factors

Unit I: Transcriptional regulation - cis- and trans-acting factors

Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Anti-termination, Combinatorial control – Regulation of lac, trp and ara Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment.

Unit II: Regulatory sequences and signal transduction

Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain–Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers. Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.

Block 2: Non-coding RNA and gene regulation

Unit I: Non-coding RNAs

Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents. Ribo-switches. Gene Silencing by RNA - siRNA & miRNA – synthesis and function. Non-coding RNAs their impact, categories and role in gene regulation, chromatin assembly *etc.*

Unit II: Auto-regulation

Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch, Oscillating pattern of gene expression.

References

- NELSON, D. L. AND COX, M. M., 2017, Lehinger's Principles of Biochemistry, 7th edition, W H Freeman Publication New York
- KREBS, J. E., GOLDSTEIN, E. S. AND KILPATRICK, S. T., 2017, Lewin's Genes XII 12th edition, Jones & Bartlett Learning publisher, Inc
- WATSON, J. D., BAKER, T. A., BELL, S. P., GANN, A., LEVINE, M., AND LONICK, R., 2014, Molecular Biology of the Gene, 7th Edition, Cold Spring Harbor Laboratory Press, New York.
- GARDNER, E. J., SIMMONS, M. J. AND SNUSTAD, D. P., 2006, Principles of Genetics (2006) eighth Edition. Wiley.

M.Sc. (Agri.) in Plant Pathology

Course Code	Course Title	Credit Hours
PAT 501	Mycology	3 (2+1)
PAT 502	Plant Virology	3 (2+1)
PAT 503	Plant Pathogenic Prokaryotes	3 (2+1)
PAT 504	Plant Nematology	3 (2+1)
PAT 505	Principles of Plant Pathology	3 (2+1)
PAT 506	Techniques in Detection and Diagnosis of Plant Diseases	2 (0+2)
PAT 507	Principles of Plant Disease Management	3 (2+1)
PAT 508	Epidemiology and Forecasting of Plant Diseases	1 (1+0)
PAT 509	Disease Resistance in Plants	2 (2+0)
PAT 510	Ecology of Soil-Borne Plant Pathogens	2 (1+1)
PAT 511	Chemicals and Botanicals in Plant Diseases Management	3 (2+1)
PAT 512	Detection and Management of Seed Borne Pathogens	3 (2+1)
PAT 513	Biological Control of Plant Diseases	2 (1+1)
PAT 514	Integrated Diseases Management	3 (2+1)
PAT 515	Diseases of Field and Medicinal crops	3 (2+1)
PAT 516	Diseases of Fruit, Plantation and Ornamental crops	3 (2+1)
PAT 517	Diseases of Vegetable and Spices crops	3 (2+1)
PAT 518	Post-Harvest Diseases	3 (2+1)
PAT 519	Plant Quarantine and Regulatory Measures	1 (1+0)
	Total	**49 (32+17)**
PAT 580	Qualifying Examination	2 (0+2)
PAT 581	Seminar-I	1 (0+1)
PAT 582	Seminar-II	1 (0+1)
PAT 591	Research-I	13 (0+13)
PAT 592	Research-II	14 (0+14)

PAT 501 MYCOLOGY (2+1)

Objectives

To study the nomenclature, classification and characters of fungi.

Theory

Block –1: Introduction, Importance, concepts and morphology of Fungi

Unit 1: Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs.

Unit 2: History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi.

Unit 3: Modern concept of nomenclature and classification of fungi.

Block 2: Kingdom: Protists and Stramenopila and their characters and classification

Unit 1 : kingdom fungi: Protists. The general characteristics of protists and lifecycle in the Phyla Plasmodiophoromycota,

Unit 2: Dictyosteliomycota, Acrasiomycota and Myxomycota.

Unit 3: Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

Block 3- Kingdom: Fungi and their characters and classification

Unit 1: Phylum: Chytridiomycota: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota.

Unit 2: Phylum: Ascomycota;Archiascomycetes, Ascomycetous, yeasts, Pyrenomycetes, Plectomycetes, Discomycetes and Loculoascomycetes, filamentous ascomycetes Erysiphales.

Unit 3: Phylum: Zygomycota: charactersitics of Zygomycets fungi.

Block 4 -Phylum: Basidiomycota and Deuteromycota characters and classification

Unit- 1: Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes.

Unit- 2: Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts.

Unit- 3: Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

Practical

- Detailed comparative study of different groups of fungi
- Collection of cultures and live specimens
- Saccardo an 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, Loculo-ascomycetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes
- Characters of Hyphomycetes and Coelomycetes and their teliomorphic andanamorphic states, Collection, preservation, culturing and identification of plantparasitic fungi
- Application of molecular approaches and techniques for identification of fungal pathogens.

Reference

- AINSWORTH, G. C., SPARROW, F. K. AND SUSMAN, H. S., 1973, The Fungi-An Advanced Treatise. Vol IV (A & B), Academic Press, New York.

- ALEXOPOULOS, C. J., MIMS, C. W. AND BLACKWELL, M., 2000, Introductory Mycology, 5th Ed. John Wiley & Sons, New York.
- MAHESHWARI, R., 2016, Fungi: Experimental Methods in Biology 2ndedn. CRC Press, US.
- MEHROTHRA, R. S. AND ARNEJA, K. R., 1990, An Introductory Mycology, Wiley Eastern, New Delhi.
- SINGH, R. S. 1982, Plant Pathogens-The Fungi, Oxford & IBH, New Delhi.
- WEBSTER, J., 1980, Introduction to Fungi. 2nd Ed. Cambridge Univ. Press, Cambridge, New York

PAT 502 PLANT VIROLOGY (2+1)

Objectives

To acquaint with the structure, virus-vector relationship, biology and management of plant viruses.

Theory

Block 1– Introduction, History, importance, general characteristics and classification of plant viruses

Unit 1: History and economic significances ofplant viruses. General and morphological characters, composition and structure of viruses

Unit 2: Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages,viroids and prions.

Unit 3: Origin and evolution ofviruses and their nomenclature and classification.

Block 2- Plant viral genome, replication and pathometabolism

Unit 1: Genome organization, replication in selected groups of plant viruses and their movement in host.

Unit 2: Response of the host to virus infection: biochemical, physiological, and symptomatical changes.

Unit 3: Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

Block 3- Detection and management of plant viruses

Unit 1: Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques.

Unit 2: Natural (R-genes) and engineering resistance to plant viruses. Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival).

Unit 3: Management of diseases caused by plant viruses.

Practical

- Study of symptoms caused by plant viruses (followed by field visit)
- Isolation and biological purification of plant viruses 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 and PCR basedtechniques)
- Exposure to basic bio-informatics 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).OGY 2+1

Reference

- BOS, L., 1964, Symptoms of Virus Diseases in Plat s. Oxford & IBH., New Delhi.
- BRUT, A. A., KRABTREE, K., DALLWITZ, M. J., BIBBS, A. J. AND WATSON, L., 1995, Virus of Plants: Descriptions and Lists from VIDE Database. CABI, Wallington.
- GIBBS, A. AND HARRISON, B., 1976, Plant Virology – The Principles. Edward Arnold, London, Hull R., 2002, Mathew's Plant Virology. 4th Ed. Academic Press, New York.

• NOORDAM D., 1973, Identification of Plant Viruses. Methods and Experiments. Oxford & IBH, New Delhi.

PAT 503 PLANT PATHOGENIC PROKARYOTES (2+1)

Objectives

To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional requirements, survival and dissemination.

Theory

Block-1: Introduction, History, importance and characteristics of Plant Pathogenic prokaryotes

Unit 1: Prokaryotic cell, History and development of Plant bacteriology, history of plant bacteriology in India.

Unit 2: Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell.

Unit 3: Structure and composition of gram negative and grampositive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccharide structure; Membrane transport; fimbriae and pili (Type IV pili);

Block 2- Plant Prokaryotic motility, physiology, genome characteristics and their survival and spread.

Unit 1: Mechanism offlagellar rotatory motor and locomotion, and bacterial movement

Unit 2: Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

Unit 3: Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopatho genic prokaryotes. Plant Protection–Plant Pathology.

Block 3- Classification and variability of plant pathogenic prokaryotes

Unit 1: Taxonomy of phytopatho genic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma.

Unit 2: The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

Unit 3: Variability among phytopatho genicprokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.

Block 4- Bacteriophages and management of diseases caused by Phyto pathogenic prokaryotes

Unit 1: Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle;

Unit 2: Classification of phages, Use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types,

Unit 3: Plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

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 genesequences
- Diagnosis and management of important diseases caused by bacteria and mollicutes

Reference

- GOTO, M., 1990, Fundamentals of Plant Bacteriology, Academic Press, New York.
- JAYARAMAN, J. AND VERMA, J. P., 2002., Fundamentals of Plant Bacteriology. Kalyani Publishers, Ludhiana.
- MOUNT, M. S. AND LACY, G. H., 1982, Phytopathogenic Prokaryotes. Vols. I, II Academic Press, New York
- SALLE, A. J., 1979, Fundamental Principles of Bacteriology 7thedn.
- VERMA, J. P., VARMA, A. AND KUMAR, D. (EDs), 1995, Detection of Plant Pathogens and their Management. Angkor Publ., New Delhi.

PAT 504 PLANT NEMATOLOGY (2+1)

Objectives

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

Theory

Block 1: Introduction, History and characteristics of Plant parasitic nematodes

Unit 1: Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology;

Unit 2: Nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit 3: Gross morphology of plant parasitic nematodes; broad classification, nematodebiology, physiology and ecology.

Block-2- Plant nematode interactions and Physiological races

Unit 1: Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit 2: Plant nematode relationships, cellular responses to infection by important phytonematodes;

Unit 3: Physiological specialization among phytonematodes.

Block –3- Integrated management of plant parasitic nematodes

Unit 1: Principles and practices of nematode management; integrated nematode management.

Unit 2: Emerging nematode problems

Unit 3: Importance of nematodes in international trade and quarantine.

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. Study of perennial pattern in Root knot nematodes.

Reference

- DROPKIN, V. H., 1980, An Introduction to Plant Nematology, John Wiley & Sons. New York.
- MAGGENTI, A. R., 1981, General Nematology, Springer-Verlag, New York.
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- SIKORA, R. A., COYNE, D., HALLMAN, J. AND TIMPER, P., 2018, Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. 3rdedn. CABI Publishing, England.
- THORNE, G., 1961, Principles of Nematology, McGraw Hill, New Delhi.

- WALIA, R. K. AND BAJAJ, H. K., 2003, Text Book on Introductory Plant Nematology ICAR, New Delhi
- WALIA, R. K. AND KHAN, M. R., 2018, A Compendium of Nematode Diseases of Crop Plants, ICAR, AICRP (Nematodes), IARI, New Delhi.

PAT 505 PRINCIPLES OF PLANT PATHOLOGY (2+1)

Objectives

To introduce the subject of Plant Pathology, its concepts and Principles.

Theory

Block-1- Importance, history, physiology of plant pathogen and epidemiology of plant diseases

Unit 1: Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit 2: Growth, reproduction, survival and dispersal of important plant pathogens.

Unit 3: Role of environment and host nutrition on disease development.

Block –2- Plant pathogen interaction

Unit 1: Host parasite interaction, recognition concept and infection, symptomatology,

Unit 2: Disease development- role of enzymes, toxins, growth regulators;

Unit 3: Defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

Block –3: Variability of plant pathogen and host plant resistance

Unit 1: Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens

Unit 2: molecular basis for resistance; marker-assisted selection;

Unit 3: Genetic engineering for disease resistance.

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.

Reference

- AGRIOS, G. N., 2005, Plant Pathology, 5th Ed. Academic Press, New York.
- HETEFUSS, R. AND WILLIAMS, P. H., 1976, Physiological Plant Pathology, Springer Verlag, Berlin, New York.
- MEHROTRA, R. S. AND AGGARWAL, A., 2003, Plant Pathology, 2nd Ed. Oxford & IBH, New Delhi.
- SINGH, R. P., 2012, Plant Pathology 2ndedn. Kalyani Publishers, New Delhi.
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PAT 506 TECHNIQUES FOR DETECTION AND DIAGNOSIS OF PLANT DISEASES (0 + 2)

Objectives

To impart training on various methods/techniques/instruments used in the study of plant diseases/pathogens.

Practical

- Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3. Cultural studies; (use of selective media to isolatepathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serologicalassays 7. Nucleic acid based techniques (Non-PCR–LAMP, Later flow microarray and 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 rDNAintergenic spacer regionsequences-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, Phagedisplay 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.

Reference

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- GIBBS, A. AND HARRISON, B., 1976, Plant Virology – The Principles. Edward Arnold, London, Hull R, 2002, Mathew's Plant Virology. 4th Ed. Academic Press. New York.
- NOORDAM, D., 1973, Identification of Plant Viruses, Methods and exponents. Oxford & IBH, New Delhi.
- WILSON, C., 2014, Applied Plant Virology, CABI Publishing England.

PAT 507 PRINCIPLES OF PLANT DISEASE MANAGEMENT (2+1)

Objectives

To acquaint with different strategies for management of plant diseases.

Theory

Block- 1- Methods of plant disease management

Unit 1: Principles of plant disease management by cultural, physical, biological, chemical methods of plant disease control

Unit 2: Organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases.

Unit 3: Disease resistance and molecular approach for disease management.

Block –2- Agrochemicals in plant disease management

Unit 1: History of fungicides, bactericides, antibiotics, concepts of pathogen and immobilization

Unit 2: chemical protection and chemotherapy, nature, properties and mode of action of antifungal

Unit 3: Antibacterial and antiviral chemicals. Label claim of fungicides.

Block- 3- Methods of application of agro chemicals and bio agents

Unit 1: Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants

Unit 2: health vis-a-vis environmental hazards, residual effects and safety measures

Unit 3: Integrated disease management, organic management of plant diseases, biological management under protected cultivation.

Practical

- Phytopathometry

- Methods of in-vitro evaluation of chemicals, antibiotics, bio agents against plantpathogens
- 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

Reference

- FRY, W. E., 1982, Principles of Plant Disease Management. Academic Press, New York.
- HEWITT, H. G., 1998, Fungicides in Crop Protection, CABI, Wallington, Marsh RW, 1972, Systemic Fungicides. Longman, New York.
- NENE, Y. L. AND THAPLIYAL, P. N., 1993, Fungicides in Plant Disease Control. Oxford & IBH, New Delhi.
- PALTI, J., 1981, Cultural Practices and Infectious Crop Diseases. Springer Verlag, New York.
- VYAS, S. C., 1993, Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PAT 508 EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES (1+0)

Objectives

To acquaint with the principles of epidemiology and its application in disease forecasting.

Theory

Block 1- Concepts, history and modeling in plant diseases

Unit 1: Epidemic concepts, simple interest and compound interest disease**,** historical development.

Unit 2: Elements of epidemics and their interaction. Structures and patterns of epidemics.

Unit 3: Modeling, system approaches and expert systems in plant pathology.

Unit 4: Genetics of epidemics. Models for development of plant disease epidemics.

Block 2- Models in plant disease loss assessment

Unit 1: Common and natural logarithms function fitting, area under disease progress curve and correction factors, inoculum dynamics.

Unit 2: Population biology of pathogens, temporal and spatial variability in plant pathogens.

Unit 3: Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment.

Block- 3- Forecasting of plant diseases

Unit 1: Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting,

Unit 2: Some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction.

Unit 3: Salient features of important forecasting models.

Reference

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- COOKE, B., JONES, D. M. AND GERETH, K. B., 2018, The Epidemiology of Plant Diseases. Springer Publications.
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- NAGARAJAN, S. AND MURLIDHARAN, K.,1995, Dynamics of Plant Diseases. Allied Publ. New Delhi.
- THRESH, J. M., 2006, Plant Virus Epidemiology, Advances in Virus Research 67, Academic Press, New York.
- VAN DER PLANK, J. E., 1963, Plant Diseases Epidemics and Control. Academic Press, New York
- ZODOKS, J. C. AND SCHEIN, R. D., 1979, Epidemiology and Plant Disease Mangement. Oxford Univ. Press. London.

PAT 509 DISEASE RESISTANCES IN PLANTS (2+0)

Objectives

To acquaint with the disease resistance mechanism in crop plants.

Theory

Block-1- Introduction, History, Variability of plant pathogens and types of resistance in crop plants

Unit 1: Introduction and historical development, dynamics of pathogenicity, process of infection,

Unit 2: Variability in plant pathogens, gene centers as sources of resistance, disease resistance terminologies.

Unit 3: Disease escape, non-host resistance and disease tolerance.

Block 2- Mechanisms and types of host resistance to diseases

Unit 1: Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen,

Unit 2: Disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Unit 3: Host defense system, morphological and anatomical resistance, pre-formed chemicals in host defense.

Block –3- Host defense strategies and management of resistance gene in plants

Unit 1: Post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms

Unit 2: Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis

Unit 3: Management of resistance genes. Strategies for gene deployment.

Reference

- DEVERALL, B. J., 1977, Defence Mechanisms in Plants. Cambridge Univ. Press, Cambridge, New York.
- MILLS DALLICE, *et al.*, 1996, Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction. APS, St Paul, Minnesota.
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- ROBINSON, R. A., 1976, Plant Pathosystems, Springer Verlag, New York.
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- VANDER PLANK, J. E., 1982, Host Pathogen Interactions in Plant Disease. Academic Press, New York.
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PAT 510 ECOLOGY OF SOIL-BORNE PLANT PATHOGENS (1+1)

Objectives

To provide knowledge on soil-plant disease relationship.

Theory

Block 1- Soil and Soil borne plant pathogens and its interaction

Unit 1: Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane,

Unit 2: Host exudates, soil and root inhabiting fungi.

Unit 3: Interaction of micro organisms.

Block 2- Bio control agents and its mode of action

Unit 1: Types of bio control agents.

Unit 2: Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

Unit 3: Conducive and suppressive soils.

Block 3- Biological management of plant diseases

Biological control-concepts and potentialities for managing soil borne pathogens. Potential of Trichoderma and fluorescent Pseudomonas in managing plant diseases.

Practical

- Quantification of rhizosphere and rhizoplanemicro flora with special emphasis on pathogens
- Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils
- Suppression of test soil-borne pathogens by antagonistic microorganisms;
- Isolation and identification of different bio control agents
- Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens
- Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants
- Estimating the rhizosphere and root tissue population of microorganisms(pathogens) in plants

Reference

- BAKER, K. F. AND SNYDER, W. C., 1965, Ecology of soil-borne Plant Pathogens. John Wiley, New York

- COOK, R. J. AND BAKER, K. F., 1983, The Nature and Practice of Biological Control of Plant Pathogens. APS, St Paul, Minnesota.
- GARRET, S. D., 1970, Pathogenic Root-infecting Fungi. Cambridge Univ. Press, Cambridge, New York.
- HILLOCKS, R. J. AND WALLER, J. M., 1997, Soil-borne Diseases of Tropical Crops. CABI, Wallington
- MONDIA, J. L. AND TIMPER, P., 2016, Interactions of microfungi and plant parasitic nematodes. In: Biology of Microfungi.
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PAT 511 CHEMICALS AND BOTANICALS IN PLANT DISEASE MANAGEMENT (2+1)

Objectives

To provide knowledge on the concepts, mode of actions, classification and judicious use of chemicals and botanicals in plant disease management**.**

Theory

Block 1- Introduction, importance, history and classification of agro chemicals

Unit 1: History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals

Unit 2: Classification of chemicals used in plant disease management and their characteristics.

Unit 3: Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, Antiviral chemicals and botanicals.

Block 2

Unit 1: Label claim, Formulation and safe usage: Issues related to label claim

Unit 2: Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides

Unit 3: Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides.

Block 3- New generation fungicides and plant protection appliances

Unit 1: New generation fungicides and composite formulations of pesticides.

Unit 2: Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases

Unit 3: General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practical

- Acquaintance with formulation of different fungicides and plant protection appliances
- Formulation of fungicides, bactericides and nematicides
- In-vitro evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens
- Persistence, compatibility with other agro-chemicals
- Detection of naturally occurring fungicide resistant mutants of pathogen
- Methods of application of chemicals

Reference

- BINDRA, O. S. AND SINGH, H., 1977, Pesticides and Application Equipment. Oxford & IBH, New Delhi
- NENE, Y. L. AND THAPLIYAL, P. N., 1993, Fungicides in Plan Disease Control. 3rd ed. Oxford & IBH. New Delhi.
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• VYAS, S. C., 1993, Hand book of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PAT 512 DETECTION AND MANAGEMENT OF SEED BORNE PATHOGENS (2+1)

Objectives

To acquaint with seed-borne diseases, their nature, detection, transmission, inoculum potential, epidemiology, impacts/losses and management.

Theory

Block 1- History, importance, quarantine and seed pathology

Unit 1: History and economic importance of seed pathology in seed industry

Unit 2: Plant quarantine and SPS under WTO.

Unit 3: Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

Block 2- Seed infection, transmission and certification

Unit 1: Recent advances in the establishment and subsequent cause of disease development in seed and seedling.

Unit 2: Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

Unit 3: Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds.

Block 3- doption of crop plants to seed infection, epidemiology and seed health management

Unit 1: Evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens.

Unit 2: Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

Unit 3: Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

Practical

- Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria, viruses and Nematodes;
- Relationship between seed-borne infection and expression of the disease in the field

Reference

- AGARWAL, K. AND SINCLAIR, J., 1993, Principles of seed Pathology, Vols. I & II CBS Publ., New Delhi.
- HUTCHINS, J. D. AND REEVS, J. E., 1997, Seed Health Testing: Progress Toward the 21st Century CABI, Wallington.
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PAT 513 BIOLOGICAL CONTROL OF PLANT DISEASES (1+1)

Objectives

To study principles and application of eco friendly and sustainable management strategies of plant diseases**.**

Theory

Block 1- Importance, concept, history, mode of actions of bio control agents

Unit 1: Concept of biological control, definitions, importance, principles of plant disease management with bio agents,

Unit 2: History of biological control, merits and demerits of biological control.

Unit 3: Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence,

Unit 4: Rhizospherecolonization, competitive saprophytic ability, antibiosis, induced resistance, Mycorrhizal associations, operational mechanisms and its relevance in biological control.

Block 2- Factors influencing biological control

Unit 1: Factors governing biological control, role of physical environment, agro ecosystem, operational mechanisms and cultural practices in biological control of pathogens.

Unit 2: Pathogens and antagonists and their relationship, bio control agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases.

Unit 3: Compatibility of bio agents with agrochemicals and other antagonistic microbes.

Block 3- Maas multiplication, quality control and delivery of bio-agents

Unit 1: Commercial production of antagonists, their delivery systems.

Unit 2: application and monitoring, biological control in IDM, IPM and organic farming system

Unit3: Bio-pesticides available in market. Quality control system of bio-control agents.

Practical

- Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen in-vitro and in vivo conditions;
- Preparation of different formulations of selected bioagents and their mass production;

- Quality parameters of biocontrol agents;
- One week exposure visit to commercial biocontrolagent's production unit.

Reference

- CAMPELL, R., 1989, Biological Control of Microbial Plant Pathogens. Cambridge Univ.
- COOK, R. J. AND BAKER, K. F., 1983, Nature and Practice of Biological Control of Plant Pathogens AP,St. Paul. Minnesota.
- GAANICKAM, S. S., 2002, biological Control of Crop Debases. CRC Press, Florida
- HEIKKI, M. T. AND HOKKANENAMES, M., 1996, Biological Control-Benefits and Risks, CambridgeUniv. Press, Cambrdge.

PAT 514 INTEGRATED DISEASE MANAGEMENT (2+1)

Objectives

To emphasize the importance and the need of IDM in the management of disease of important crops.

Theory

Block I- Introduction, components of IDM

Unit- I: Introduction, definition, concept and tools of disease management.

Unit- II: Components of integrated disease management- their limitations and implications.

Block II- Principles of plant disease management

Unit- I: Development of IDM-basic principles.

Unit- II: Biological, chemical and cultural disease management.

Block III- IDM in Field and Horticulture crops

Unit- I: IDM in important crops- rice, wheat, cotton.

Unit- II: sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses.

Unit- III: Vegetable crops, fruit, plantation and spice crops.

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

Reference

- Gupta, V. K. and Sharma, R. C., 1995, Integrated Disease Management and Plant Health. Scientific Publ., Jodhpur.
- MAYEE, C. D., MANOHARACHARY, C. TILAK., KVBR, Mukadam DS and DeshpandeJayashree, 2004, Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.
- SHARMA, R. C. AND SHARMA, J. N., 1995, Integrated Plant Disease Management. Scientific Publ., Jodhpur.

PAT 515 DISEASES OF FIELD AND MEDICINAL CROP (2+1)

Objectives

To acquaint with diseases of field and medicinal plants and their management.

Theory

Block 1- Diseases of cereal and pulse crops

Unit 1: Diseases of Cereal crops- Rice, wheat and barley,

Unit 2: Diseases of Pearl millet, sorghum and maize.

Unit 3: Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

Block 2- Diseases of oil seed and cash crops

Unit 1: Diseases of Oilseed crops- Rapeseed and mustard, sesame and linseed,

Unit 2: Diseases of sunflower, groundnut and castor.

Unit 3: Diseases of Cash crops- Cotton and sugarcane.

Block 3- Diseases of fodder legumes and medicinal crops

Unit 1: Diseases of Fodder legume crops- Berseem, oats, guar and lucerne.

Unit 2: Diseases of medicinal crops- Plantago, liquorice, mulathi androsagrass

Unit 3: Diseases of sacred basil, menthe, ashwagandha and Aloe vera.

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

Reference

- JOSHI, L. M., SINGH, D. V. AND DRIVASTAVA, K. D., 1984, Problems and Progress of Wheat pathology in South Asia. Malhotra Publ. House, New Delhi.
- RANGASWAMI, G., 1999, Diseases of crop Plants in India, 4th Ed. Prentice Hall of India, New Delhi.
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- Study of different natural enemies of eri silkworm;
- Study of different diseases of eri silkworm;
- Practising of tasar egg production;
- Economics of eri silkworm rearing;
- Visit

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- JOLLY, M. S, SEN, S. K. AND AHSAN, M. M., 1974, *Tasar culture*. Ambika Publishers, Bombay.
- JOLLY, M. S., SEN, S. K. SONWALKAR, T. N. AND PRASAD, G. K., 1979, *Sericulture Manual - 4 – Non-MulberrySilks*. Agriculture Service Bulletin, FAO, Rome.
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- SARKAR, D. C., 1980, *Ericulture in India*. Central Silk Board, Bangalore.

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- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
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Websites

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- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 516 SERICULTURE BY-PRODUCT UTILIZATION AND VALUE ADDITION (1+1)

Objective

- To understand the best utilization of by-products generated at each stage of sericultural activity
- To know the value addition of each byproduct for generating additional income making them good entrepreneurial managers in sericulture.

Theory

Block 1: Entrepreneurship in sericulture

Unit 1: Entrepreneurship in sericulture- prospects and problems

Concept, need, scope, prospects and problems of entrepreneurship in sericulture.

Unit 2: Sericultural entrepreneurship development in different countries

Sericultural entrepreneurial development in India, China, Japan, Korea, Thailand and Brazil.

Block 2: Entrepreneurship development in different areas of Sericulture

Unit 1: Entrepreneurship development in mulberry cultivation

Entrepreneurship development in mulberry cultivation- kisan nursery, composting, vermicomposting, bio-digester, bio-gas production, livestock production, fisheries, mushroom cultivation and silage production.

Unit 2: Entrepreneurship development in egg production and silkworm rearing

Entrepreneurial development in silkworm-egg production, Chawki rearing and cocoon production.

Unit 3: Entrepreneurship development in silk reeling and post reeling activities

Entrepreneurship development in silk reeling – establishment of reeling units, twisting and dying units, weaving units. Entrepreneurship development in seri-inputs, manufacture/ production, marketing/ custom hiring of sericulture material/equipment.

Block 3: Value addition to by-products in sericulture

Unit 1: Value addition to mulberry products

Value addition to mulberry- mulberry as fuel, green manure, fodder, live fencing material, wind breaks. Mulberry fruits and their use in pickle, jam, jelly, beverage/wine preparation. Mulberry as medicine, mulberry in agriculture and sports industry, mulberry in biogas production, mulberry as shade and avenue tree. Processing of mulberry leaves for tea preparation and food products. Medicinal value of mulberry.

Unit 2: Value addition during silkworm rearing

Value addition during silkworm rearing –silkworm litter as livestock feed; as an organic manure, raw material for biogas production, mushroom raising, poultry feed, fish feed, silkworm excreta in cosmetic industry. Silkworm in human consumption.

Unit 3: Value addition to byproducts of silk reeling

Pupal oil extraction and its uses, pupal powder as animal feed and manure. Flimsy cocoons and waste cocoons used as raw material in spun silk industry and quilting purpose. Silkworm pupa in human consumption-commercialized products and locally prepared dishes. Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc., from waste cocoons. Sericin in medicine, cosmetics, artificial membranes and plastic industry and other uses of silk.

Practical

- Visit to grainage for collection of waste cocoons including pierced cocoons;

- Visit to Chawki rearing centres and cocoon production centres for collection of different by-products;
- Visit to Silk reeling, twisting, dying and weaving units for collection of different by-products;
- Preparation of compost, vermi-compost and bio-digester from mulberry waste;
- Value addition to byproducts of mulberry products-mulberry as fuel, green manure, fodder, live fencing material, wind breaks;
- Estimation of calorific value of mulberry wood as fuel;
- Mulberry fruits for table purpose and preparation of pickles, juice, jam, jelly, beverage/wine;
- Raising of mulberry saplings from desired genotypes for social forestry, avenue tree and eco-friendly flora;
- Processing of mulberry leaf for the tea preparation;
- Preparation of different food products with mulberry leaf as ingredient;
- Mushroom cultivation using silkworm litter as substrate;
- Value addition to silkworm rearing waste – silkworm litter as cattle, sheep and goat feed;
- Preparation of mulberry silage along with popular fodders;
- Quantification of biogas production using silkworm waste;
- Pupal oil extraction and pupal powder preparation and nutrient status estimation;
- Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc. using waste cocoons;
- Estimation of manurial value of compost and vermi-compost derived from mulberry waste;
- Silkworm pupae as animal, fishery and poultry feed.

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- ANONYMOUS, 2002, *Colours from Nature – Silk Dyeing Using Natural Dyes.* Vol. I and II, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
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- SINHA, S., 1990, *The Development of Indian Silk*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- TAZIMA, Y., 1978, *The Silkworm: An Important Laboratory Tool*. Kodansha Ltd., Tokyo.
- TRIPURARI SHARAN., 1984, *Sericulture and Silk Industry*. Published by Y.K. Sharma, Consortium on Rural Technology, Delhi.
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M.Sc. (Agri.) in Soil Science

Course Code	Course Title	Credit Hours
SSC 501	Soil physics	3 (2+1)
SSC 502	Soil fertility and fertilizer use	3 (2+1)
SSC 503	Soil chemistry	3 (2+1)
SSC 504	Soil mineralogy, genesis and classification	3 (2+1)
SSC 505	Soil erosion and conservation	3 (2+1)
SSC 506	Soil Biology and Biochemistry	3 (2+1)
SSC 507	Radioisotopes in soil and plant studies	2 (1+1)
SSC 508	Soil, water and air pollution	3 (2+1)
SSC 509	Remote sensing and GIS technique for soil and crop studies	3 (2+1)
SSC 510	Analytical technique and instrumental methods in soil and plant Analysis	2 (0+2)
SSC 511	Management of problematic soils and water	2 (1+1)
SSC 512	Land degradation and restoration	1 (1+0)
SSC 513	Soil Survey and Land use Planning	2 (2+0)
SSC 514	Introduction to nanotechnology	3 (2+1)
	Total	**36 (23+13)**
SSC 580	Qualifying Examination	2 (0+2)
SSC 581	Seminar-I	1 (0+1)
SSC 582	Seminar-II	1 (0+1)
SSC 591	Research-I	13 (0+13)
SSC 592	Research-II	14 (0+14)

SSC 501 SOIL PHYSICS (2+1)

Objective

To impart basic knowledge about soil physical properties and process in relation to plant growth.

Theory

Block I

Unit 1: Basic principles of physics applied to soils, soil as a three phase system.

Unit 2: Soil texture, textural classes, mechanical analysis, specific surface.

Unit 3: Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

Unit 4: Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Block II

Unit 1: Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

Unit 2: Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

Unit 3: Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

Unit 4: Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

Unit 5: Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

References

- ARUNA KUMAR SAHA, Text book of Physics
- ISSS, New Delhi, Fundamentals of Soil Science
- K. RAMASWAMY, S. MAHIRAGIRA, SHRINE JUNTA RAJMAHAL, J RAMA CHANDRAN AND ANJITHA, Text book on soil Physics
- MANOJ K. SHUKLA, Soil physics – An Introduction
- RATTANLAL AND MONOJ K. SHUKLA, Principles of Soil physics
- T. J. MARSHALL, J.W HOLMES AND C.W. ROSE, Soil physics

- WILLIAM A. JURY AND ROBERT HORTON, Soil Physics
- KOHUKE, HELMUT, Soil Physics

SSC 502 SOIL FERTILITY AND FERTILIZER USE (2+1)

Objective:

To impart basic knowledge about soil fertility and its importance and to understand the role of fertilizers and manures in supplying nutrients to plants so as to increase fertilizer use efficiency and productivity.

Theory:

Block I

Unit 1: 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.

Unit 2: 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 3: 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, equilibriumin soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit 4: 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.

Block II

Unit 1: 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 2: Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.

Unit 3: Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; specialty fertilizers concept, need and category. Current status of specialty fertilizers use in soils and crops of India;

Unit 4: Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

Unit 5: Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.

Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients (major and micro)
- Analysis of plants for essential elements (major and micro)

References

- HAVLIN, TISDALE, NELSON AND BEATON - Soil fertility and fertilizers
- ISSS, New Delhi, Fundamentals of Soil Science
- BOYD ELLIS AND HENRY FOTH - Soil fertility
- JADEJA, HIRPARA, VEKARIA AND SAKARVADIA - Soil fertility and nutrient management
- ALFRED VIVIAN Principles of Soil fertility
- RAM LAKHN RAM, Current Research in Soil fertility

SSC 503 SOIL CHEMISTRY (2+1)

Objective

To introduce the basic concepts of soil chemistry and to familiarize students with modern developments in chemistry in relation to soil as a medium for plant growth and development.

Theory

Block I

Unit 1: Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit 2: Elements of equilibrium thermodynamics, chemical equilibria, electro chemistry and chemical kinetics.

Unit 3: Soil colloids: inorganic and organic colloids – origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation / flocculation and peptization of soil colloids; electro metric properties of soil colloids; sorption properties of soil colloids; soil organic matter-fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit 4: 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 activity measurement, the rmodynamics, statistical mechanics; anionandlig and exchange– inner sphere and outer-sphere surface complexformation, fixation of oxyanions, hysteresis insorption-desorption of oxy-anionsandanions, shift of PZ Conligand exchange, AEC, CEC; experimental methods to study ionexchange phenomena and practical implications in plant nutrition.

Unit 5: 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.

Block II

Unit 1: Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit 2: Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments

Unit 3: Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry.

Practical

Preparation of saturation extract, measurement of pH, EC, CO_3, HCO, 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 potentio metric titration method, Extraction of humic substances, Potentiometric and conduct ometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectro photometric studies and the D (E4/E6) values at two pH values, Adsorption-desorption of phosphate / sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate / fluoride / sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by $BaCl_2$-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

References

- KIM. H. TAN – Principles of Soil Chemistry
- SAROJ KUMAR SANYAL - Text Book of Soil Chemistry
- L. BHATTACHARYA - Text Book of Soil Chemistry
- ISSS, New Delhi - Fundamentals of Soil Science
- PREMASIS SUKUL - Soil Chemistry and Plant Nutrients

- R. B. MEHRA - Text Book of Soil Science
- DILIP KUMAR DAS - Introductory Soil Science

SSC 504 SOIL MINERALOGY, GENESIS AND CLASSIFICATION (2+1)

Objective

To impart and acquaint students with basic structure of clay minerals, genesis terms of factors and processes of soil formation, and to enable the students to classify soils into different land use systems.

Theory

Block I

Unit 1: Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit 2: Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Block II

Unit 1: Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit 2: Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps–usefulness.

Practical

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions

- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available database in terms of soil quality

References

- GRAHAM AND MCDANIEL - Soil genesis and Classification
- ISSS, New Delhi - Fundamental of Soil Science
- J. SEHGAL - A Text Book of Pedology (Concepts and Application)
- BRADY, N. C. - Nature and Properties of Soil
- T. D, BISWAS AND S. K. MUKHERJEE - Text Book of Soil Science
- BUO L. S. W., HOLE F. D., M. C. GRACKEN R. J. AND SOUTH - Soil genesis and Classification

SSC 505 SOIL EROSION AND CONSERVATION (2+1)

Objective:

To enable students to understand various types of soil erosions and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

Block I

Unit 1: History, distribution, identification and description of soil erosion problems in India.

Unit 2: Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity –estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of run off; soil losses in relation to soil properties and precipitation.

Unit 3: Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

Unit 4: Principles of erosion control; erosion control measures– agronomical and engineering; erosion control structures - their design and layout.

Block II

Unit 1: Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, water logged and wet lands.

Unit 2: Water shed management- concept, objectives and approach; water harvesting and recycling; flood control in water shed management; socio economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

Practical

- Determination of different soil erodibility indices-suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, rain drop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rain fall erosivity index (EI30) using rain gauge data
- Land capability classification of a watershed
- Visits to watersheds

References

- MORGAN AND JOHN WILEY - Soil Erosion and Conservation
- ARGOSIAA - Fundamental of Soil Conservation
- GUSTAFSON - Conservation of the Soil
- MADIREDDY V SUBBA RAO - Soil Conservation, Management and analysis

SSC 506 SOIL BIOLOGY AND BIOCHEMISTRY (2+1)

Objective

To impart knowledge to the students about basics of soil biology, biochemistry, biogeochemical cycles, plant growth promoting rhizo bacteria and microbial interactions in the soil.

Theory

Block I

Unit 1: Soil biota, soil microbial ecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

Unit 2: Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of micro flora; Root rhizosphere and PGPR.

Unit 3: Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients.

Block II

Unit 1: organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

Unit 2: Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermin compost.

Unit 3: Biofertilizers-definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of bio fertilizers.

Unit 4: Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis – important mechanisms and controlling factors; soil genomics and bio prospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

Practical

- Determination of soil microbial population
- Soil microbial biomass carbon
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N_2 fixation, S oxidation, P solubilization and mineralization of other micronutrients

References

- DAR GHULAM HASSAN - Soil Microbiology and Biochemistry
- ELDORA A PAUL - Soil Microbiology. Ecology and Biochemistry
- S. K. VERMA AND MOHIT VERMA - A Text Book of Plant Physiology, Bio Chemistry and Biotechnology
- CHHONKAR, BHADRARAY, PATRA AND PURAKAYASTHA - Soil Biology and Biochemistry
- PRASAD - Text Book of biochemistry

SSC 507 RADIO ISOTOPES IN SOIL AND PLANT STUDIES (1+1)

Objective

To teach and train the students in the field of radioisotopes use in soil and plant research.

Theory

Block I

Unit 1: Atomic structure, radio activity and units; radio isotopes-properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity

Unit 2: Principles and use of radiation monitoring instruments-proportional, Geiger Muller counter, solid and liquids scintillation counters; neutron moisture meter, mass spectrometry, autoradiography.

Block II

Unit 1: Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

Unit 2: Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

- Storage and handling of radioactive materials
- Determination of half-life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radio isotopes
- Determination of A, E and L values of soil using 32P/65Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of 15N enrichment by mass spectrophotometery/ emission spectrometry

References

- BHUPINDER SINGH - Radioisotopes in Soil and Plant Studies

SSC 508 SOIL, WATER AND AIR POLLUTION (2+1)

Objective:

To sensitize and make aware to the students about the pollution problems occurring in soil, water and air and its effect on crop production and its remedial measures.

Theory

Block I

Unit 1: Soil, water and air pollution problems associated with agriculture, nature and extent.

Unit 2: Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPC standards and effect on plants, animals and human beings.

Unit 3: Sewage and industrial effluents–their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

Unit 4: Pesticides–their classification, behavior in soil and effect on soil microorganisms.

Block II

Unit 1: Toxic elements-their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

Unit 2: Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of green house gases–carbondioxide, methane and nitrous oxide.

Unit 3: Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammonical nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO_2 and O_2 conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

References

- VIJENDRA SINGH - Environmental Chemistry (Water and soil Pollution) -
- CHEE KONG YAP - Soil Pollution
- K. K. SINGH, ASHA JUWARKAR, A. K. SINGH AND ALKATOMAR - Air, Water and Soil Pollution
- PAUL PETRUCIS - Air, Water and Soil Pollution
- PRADYOT PATNAIK - Hand Book of Environmental analysis
- WILEY - Sustainable Solutions For Environmental Pollution

SSC 509 REMOTE SENSING AND GIS TECHNIQUE FOR SOIL, WATER AND CROP STUDIES (2+1)

Objective

To impart knowledge about the basic concepts of remote sensing, aerial photographs, imageries, their interpretation, application of remote sensing in general and with special reference to soils, plants and yield forecasting, to upgrade knowledge about geo statistical techniques with special reference to krigging and GIS and applications in Agriculture.

Theory

Block I

Unit 1: Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

Unit 2: Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyper spectral imaging, thermal imaging; image processing and interpretations.

Unit 3: Application of remote sensing techniques-land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land identification and management.

Block II

Unit 1: Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

Unit 2: Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photo graphs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geo statistical techniques, Creation of data files in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

References:

- A. K. KOLAY - Remote Sensing and Assessment of Soil Resources
- M. ANJI REDDY - Text Book of Remote Sensing and Geographical information Systems
- KALI CHANDRA SAHU - Text Book of Remote Sensing and Geographical information Systems
- G. S. SRIVASTAVA - An Information to Geo informatics
- AJAY PRAKASH - Remote Sensing and Geographical Information Systems
- JOHN R. JENSEN - Remote Sensing of the Environment

SSC 510 ANALYTICAL TECHNIQUE AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS (0+2)

Objective

To train and familiarize the students with commonly used

UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

COURSE SYLLABUS
FOR
Ph.D. DEGREE PROGRAMME

2022-23

DIRECTORATE OF POST GRADUATE STUDIES
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CONTENTS

* Stand-alone Programme

Operational Field Guide for Developing and Managing Local Agricultural Innovation Platforms. Australian Centre for International Agricultural Research. https://www.aciar.gov.au/file/103711/download? token= EPYmwxnE

- MITTAL. N, SULAIMAN, R.V. AND PRASAD, R. M. 2016. *Assessing Capacity Needs of Extension and Advisory Services A Guide for Facilitators.* Agricultural Extension in South Asia. http://www.aesanetwork.org/assessing-capacity-needs-of-extension-and-advisory-services-a-guide-for-facilitators/
- NGWENYA. H, AND KIBWIKA. P, 2016. *NELK Module 7 Introduction to Facilitation for Development, New Extensionist Learning Kit (NELK), Global Forum for Rural Advisory Services(GFRAS).*
- http://www.g-fras.org/en/knowledge/new-extensionist-learning-kit-nelk.html#module-7-introduction-for facilitation-for-development
- Otim, R. L. 2013. *Facilitation Skills Training Manual: A facilitator's handbook.* United States Agency for International Development (USAID).
- https://publiclab.org/system/images/photos/000/020/662/original/FACILITATION_SKILLS_TRAINING_Manual.pdf

Ph.D. in Agronomy

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

AGR 601 CURRENT TRENDS IN AGRONOMY (3+0)

Objective

To acquaint the students about recent advances in agricultural production

Theory

Block I: Agro-physiological basis for crop production

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

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

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

Block II: Recent trends in crop production

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

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

References

- AGARWAL, R. L. 1995. *Seed Technology*. Oxford & IBH.
- DAHIYA, B. S AND RAI, K. N. 1997. *Seed Technology*. Kalyani.
- GOVARDHAN, V. 2000. *Remote Sensing and Water Management in Command Areas: Agroecological Prospectives*. IBDC.
- ICAR. 2006. *Hand Book of Agriculture*. ICAR.
- NARASAIAH, M. L. 2004. *World Trade Organization and Agriculture*. Sonali Publ.
- PALANIAPPAN, S. P. AND ANNADURAI, K. 2006. *Organic Farming - Theory and Practice*. Scientific Publ.
- SEN, S. AND GHOSH, N. 1999. *Seed Science and Technology*. Kalyani.

- TARAFDAR, J. C, TRIPATHI, K. P, AND KUMAR, M. 2007. *Organic Agriculture* Scientific Publ.
- KUMAR, R, SWARNKAR K.S, SINGH K.S AND NARAYAN S. 2016. *A Text Book of Seed Technology*. Kalyani Publication.
- REDDY, S. R. AND PRABHAKARA, G. 2015. *Dryland Agriculture*. Kalyani Publishers.
- GURURAJAN, B., BALASUBHRAMANIAN, R. AND SWAMINATH, V., 2013. *Recent Strategies on Crop Production*. Kalyani Publishers.
- VENKATESWARLU, B. AND SHANKER,. ARUN, K., 2009. *Climate change and agriculture: Adaptation and mitigation strategies*. *Indian Journal of Agronomy* **54**(2): 226-230.

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

Objective

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

Theory

Block I: Crop growth and analysis

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

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

Block II: Crop growth and yield relationship

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

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

Practical

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

References

- CHOPRA, V. L. AND PARODA, R. S. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. Oxford & IBH.
- DELVIN, R. M AND VITHAM, F. H. 1986. *Plant Physiology*. CBS Publ.
- EVANS, L. T. 1975. *Crop Physiology*. Cambridge Univ. Press.

- EVANS, L. T. 1996. *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press.
- GUPTA, U. S. (Ed.). 1995. *Production and Improvement of Crops for Drylands*. Oxford & IBH.
- GUPTA, U. S. 1988. *Progress in Crop Physiology*. Oxford & IBH.
- KRAMER, P. J. AND BOYER, J. S. 1995. *Water Relations of Plant and Soils.* Academic Press.
- MUKHERJEE, S. AND GHOSH, A. K. 1996. *Plant Physiology*. Tata McGraw Hill.
- NARWAL, S.S., POLITYCKA, B. AND GOSWAMI, C. L. 2007. *Plant Physiology: Research Methods.*

  Scientific Pub.
- TIAZ, L. AND ZEIGER, E. 2006. Plant Physiology. Sinauer Associates, Inc.

AGR 603 IRRIGATION MANAGEMENT (2+1)

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

Theory

Block I: Water resources and its utilization

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

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

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

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

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

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

Block II: Water resource management

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

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

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

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

Unit 5: Crop water production function

Practical

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

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

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

Objective

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

Theory

Block I: Biology and management of weeds

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

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

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

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

Block II: Recent trends in herbicide technology

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

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

Unit 3: Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelo chemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical

weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

References

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

Objective

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

Block I: Integrated farming system and concepts of sustainability

Unit 1: Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/ irrigated condition in different land situation. farming systems

according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

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

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

Block II: Farming system models and evaluation

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

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

References

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

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

Theory

Block I: Soil conservation

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

Unit 2: Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry

farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

Block II: Watershed management

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

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

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

Practical

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

References

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AGR 607 STRESS CROP PRODUCTION (2+1)

Objective

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

Theory

Block I: Moisture and temperature stress

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

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

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

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

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

Block II: Salt stress and mechanical impedance

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

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

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

Practical

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

References

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AGR 608 RESEARCH AND PUBLICATION ETHICS (2+0)

Objective

To teach about the Research and Publication Ethics

Theory

Block I: Philosophy of research

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

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

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

Reference

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- ANDREAS, D. B. AND OUELLETTE, B. F. F., (Eds), 2004,. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins 3rd Edition, Wiley Interscience.
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MBB 609 ADVANCES IN BIOFUEL BIOTECHNOLOGY (1+1)

Objective

1. To provide knowledge about biofuel and its advantages over fossil fuel and biotechnological tools in modification of plants and microbes to produce biofuel
2. To study different biotechnological strategies in producing chemical free biodiesel.

Theory:

Block I: Biofuel over fossil fuel

Unit I: Introduction to biofuels, types (biogas, biodiesel, ethanol, methanol, hydrogen and butanol) and their advantages over fossil fuel. Energy security, supply and economic sustainability of biofuels.

Unit II: Biotechnological tools in modification of plants for reducing the lignin content, and to increase the fermentable sugars and high biomass yield. Biotechnological approaches for engineering the plants and microbes for biofuel production.

Block II: Production of biodiesels through biotechnological approaches

Unit I: Biodiesel –Production of biodiesel from different oils through esterification and study of different microorganisms for extraction of enzymes to convert the oil to biodiesel. Development of recombinant microbes to increase the efficiency to produce the biodiesel. Purification of biodiesel and biochemical techniques used for characterization of biodiesel.

Unit II: Bioethanol- production of biofuels from commercial, agricultural, industrial, and domestic wastes through biotechnological approaches. Recent advances in metabolic engineering of microorganisms for advancing lignocellulose-derived biofuels. Environmental aspects of ethanol as a biofuel. Hydrogen fuel cell and microbial feed cell.

Practicals

- Utilization of different microbes for extraction of enzymes for production of biodiesel and bioethanol.
- Production of biodiesel from oil through esterification by using chemical and enzymatic method.
- Development of recombinant microbes/enzymes for production of biofuels.
- Biochemical characterization of biofuel and analysis of biodiesel quality by density, kinematic viscosity, GCMS and other techniques.

References

- ECKERT, C, A. AND TRINH, C, T., 2016, Biotechnology for Biofuel production and Optimization, Elsevier,
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Ph.D. in Plant Pathology

Course Code	Course Title	Credit Hours
PAT 601	Advances in Mycology	3 (2+1)
PAT 602	Advances in Virology	3 (2+1)
PAT 603	Advances in Plant Pathogenic Prokaryotes	3 (2+1)
PAT 604	Molecular Basis of Host-pathogen Interaction	3 (2+1)
PAT 605	Principles and Procedures of Certification	1 (1+0)
PAT 606	Plant Biosecurity and Biosafety	2 (2+0)
PAT 607	Advances in Plant Nematology	3 (2+1)
PAT 608	Seed Pathology	2 (1+1)
	Total	**20 (12+8)**
PAT 680	Qualifying Examination	3 (0+3)
PAT 681	Seminar - I	1 (0+1)
PAT 682	Seminar - II	1 (0+1)
PAT 683	Teaching Assistantship - I	1 (0+1)
PAT 684	Teaching Assistantship - II	1 (0+1)
PAT 691	Research - I	18 (0+18)
PAT 692	Research - II	18 (0+18)
PAT 693	Research - III	18 (0+18)
PAT 694	Research - IV	18 (0+18)

PAT 601 ADVANCES IN MYCOLOGY (2+1)

Objectives

To acquaint with the advances in mycology *viz*: Recent classification, conidial ontogeny, population biology and morphological and molecular classification of fungi.

Theory

Block 1- Introduction, importance, history and Recent taxonomy of fungi

Unit 1: General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification.

Unit 2: Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy.

Unit 3: Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.

Block 2- Variability in fungi

Unit 1: Population biology, pathogenic variability/ vegetative compatibility. Heterokaryos is and parasexual cycle.

Unit 2: Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance.

Unit 3: Mechanism of extra-nuclear inheritance. Biodegradation.

Block 3- Physiology and reproduction of fungi

Unit 1: Ultra structures and chemical constituents of fungal cells, functions of cell organelles.

Unit 2: Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms;

Unit 3: Parasitism, symbiosis and commensalism in fungi.

Unit 4: Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles – characterization process and application. Mycotoxins problems and its management.

Practical

- Isolation, purification and identification of cultures, spores and mating type determination;
- Study of conidiogenesis - Phialides, porospores, arthospores
- Study of fruiting bodies in Ascomycotina

- Identification of fungi up to species level
- Study of hyphal anastomosis
- Morphology of representative plant pathogenic genera forms different groups of fungi;
- Molecular characterization of fungi

References

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- MAHESHWARI, R. 2016, Fungi: Experimental Methods in Biology 2ndedn. CRC Press, US
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- WEBSTER, J. AND WEBER, R., 2007, Introduction to Fungi, Cambridge University Press, Cambridge.

PAT 602 ADVANCES IN VIROLOGY (2+1)

Objectives

To educate about the advanced techniques and new developments in plant virology

Theory

Block 1: Structure, morphology and evolution of plant viruses

Unit 1: Origin, evolution and interrelationship with animal viruses.

Unit 2: Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells.

Unit 3: Mechanisms leading to the evolution of new viruses / strains: mutation, recombination, pseudo-recombination, component re-assortment, *etc.*

Block 2- Taxonomy of vectors, virus vector relationship and serology

Unit 1: Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors.

Unit 2: Terminologies used inimmunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses.

Unit 3: Immuno/ serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid based assays for detection of plant viruses.

Block 3 Molecular diagnosis, genome organization and replication of plant viruses

Unit 1: Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non PCR based: LAMP, Fluorescent in situhybridization (FISH), dot blot hybridization.

Unit 2: Plant virus genome organization(General properties of plant viral genome- information content, coding and non-coding regions), replication

Unit 3: transcription and translational strategies of pararetro viruses, gemini viruses, tobamo-poty, bromo, cucumo, ilar, tospo viruses, satellite viruses and satellite RNA.

Block 4- Genetic engineering and transgenic plants in plant viruses management

Unit 1: Gene expression, regulation and viral promoters. Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes.

Unit 2: Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials.

Unit 3: Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

Practical

- Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation
- Acquaintance with different serological techniques (i) DAC- ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation and autoradiography
- PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny)
- Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs)

References

- DAVIES,1997, Molecular Plant Virology: Replication and Gene Expression. CRC Press, Florida
- FAUQUET *et al.,* 2005, Virus Taxonomy, VIII Report of ICTV. Academic Press, New York.
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- THRESH, J. M., 2006, Advances in Virus Research. Academic Press, New York

PAT 603 ADVANCES IN PLANT PATHOGENIC PROKARYOTES (2+1)

Objectives

To learn about the latest developments in all the plant pathogenic prokaryotes as a whole.

Theory

Block 1: Ultra structure and physiology of plant pathogenic prokaryotes

Unit 1: Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation.

Unit 2: Structure and composition (bacteria) cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili)

Unit 3: Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof Parmas (EMP) pathway, Phosphoketolase Pathway and Entner Doudor off Pathway).

Block 2: Taxonomy and nomenclature of plant pathogenic prokaryotes

Unit 1: Current trends in taxonomy and identification of phytopathogenic prokarya: International code of nomenclature, Polyphasic approach,

Unit 2: New/ special detection methods for identification of bacterial plant pathogens.

Unit 3: Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.

Block 3: Bacterial genetics and Bacteriophages

Unit 1: Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability.

Unit 2: Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal genetransfer, Bacterial Pan-Genome

Unit3: Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, *etc*.

Block 4- **Host pathogen interactions**

Unit 1: Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems

Unit 2: Pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.

Unit 3: Beneficial Prokaryotes -Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defense. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

Practical

- Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, MLST profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore,

specific detection of phytopathogenic bacteria using species/ pathovarspecific primers

- Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts
- Important and emerging diseases and their management strategies.

References

- DALE, J. W. AND SIMON, P., 2004, Molecular Genetics of Bacteria. John Wiley & Sons, New York
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PAT 604 MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION (2+1)

Objectives

To understand the concepts of molecular biology and biotechnology in relation to host plant-pathogen interactions**.**

Theory

Block 1: History, role of biotechnological tools and Importance of host pathogen relationship

Unit 1: History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology.

Unit 2: Basic concepts and principles to study host pathogen relationship.

Unit 3: Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes and their interactions.

Block 2- Plant microbe interactions

Unit 1: Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions.

Unit 2: Plant innate immunity: PAMP/ DAMP.

Unit 3: Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

Block 3- Defense mechanism in Plants

Unit 1: Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance,

Unit 2: Pathogenesis related proteins, phytoalexins and virus induced gene silencing.

Unit 3: Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes.

Unit 4: Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Meta populations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops *vs.* natural populations, Durability of resistance, erosion of quantitative resistance.

Block 4- Variability in plant pathogens

Unit 1: Pathogen population genetics and durability, viruses *vs* cellular pathogens.

Unit 2: Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity.

Unit 3: Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Practical

- Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation
- Gene mapping and marker assisted selection
- Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

References

- CHET, I., 1993, Biotechnology in Plant Disease Control John Wiley & Sons, New York
- GURR, S. J., MC POHERSEN, M. J. AND BOWLOS, D. J., 1992, Molecular Plant Pathology-A Practical Approach. Vol. I & II. Oxford Univ. Press, Oxford.
- MATHEW, J. D., 2003, Molecular Plant Pathology, Bios Scientific Publ., UK
- RONALD, P. C., 2007, Plant-Pathogen Interactions; Methods in Molecular Biology. New Jersey.
- STACEY, G. AND KEEN, T. N. (Eds.), 1996, Plant Mirobe Interactions. Vols. I-III, Chapman & Hall, New York; Vol. IV. APS Press, St.Paul, Minnesota.

PAT 605 PRINCIPLES AND PROCEDURES OF CERTIFICATION (1+0)

Objectives

To acquaint with the certification procedures of seed and planting material**.**

Theory

Block 1: Seed certification

Unit 1: Introduction to certification. International scenario of

certification and role of ISTA, EPPO, OECD, *etc.* in certification and quality control.

Unit 2: Case studies of certification systems of USA and Europe.

Unit 3: National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification.

Block 2: Seed health management

Unit 1: Methods for testing genetic identity, physical purity, germination percentage, seed health, *etc.*

Unit 2: Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.

Unit 3: Methods used in certification of seeds, vegetative propagules and in-vitro cultures.

Unit 4: Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

Reference

- TUNWAR, N. S. AND SINGH, S. V., 1988, Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation. Ministry of Agriculture, Government of India, New Delhi. US National Seed Health System.

PAT 606 PLANT BIOSECURITY AND BIOSAFETY (2+0)

Objectives

To facilitate deeper understanding on plant biosecurity and biosafety issues in agricultures.

Theory

Block 1: History and introduction to bio security and bio safety

Unit 1: History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine,Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases.

Unit 2: Introduction and History of biosecurity and its importance.

Unit 3: National Regulatory Mechanism and International Agreements / Conventions, *viz.*, Agreement on Application of Sanitary and Phytosanitary (SPS) Measures.

Block 2: Pest risk analysis and assessment models and information system

Unit 1: World TradeOrganization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system.

Unit 2: Early warning and forecasting system, use of Global PositioningSystem (GPS) and Geographic Information System (GIS) for plant biosecurity,pest/disease and epidemic management,

Unit 3: Strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Block 3: Bio safety, regulatory mechanism and issues

Unit 1: Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications

Unit 2: Issues related to release of genetically modified crops. Emerging/resurgence of pests and diseases in the changing scenario of climatic conditions.

Reference

- GROTTO ANDREW, J. AND JONATHAN B. TUCKER, 2006, Biosecurity Guidance
- KHETARPAL, R. K. AND KAVITA GUPTA., 2006, Plant Biosecurity in India-Status and Strategy. Asian Biotechnology and Development Review 9(2):3963.

• RANDHAWA, G. J., KHETARPAL, R. K., TYAGI, R. K. AND DHILLON, B. S., 2001, Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.

PAT 607 ADVANCES IN PLANT NEMATOLOGY (2+1)

Objectives

To educate about the advanced techniques and new developments in plant Nematology.

Theory

Block 1: Plant parasitic nematode physiology and interaction with host and other organism

Unit 1: Nematode anatomy, morphology, biology and ecology, Phylogenetic and evolutionary concepts.

Unit 2: Nematode ecology, habitat variations and associated factors influencing nematodes, effects of biotic and abiotic factors on host–nematode interaction,

Unit 3: Studies on the interaction of nematodes with other microorganisms including arthropods.

Unit 4: Molecular, cytogeneticall and serological approaches, fine structures in systematic. Culturing, survival ,adaptive biology and variability.

Block 2: Chemical ecology of plant parasitic nematodes

Unit 1: Sex determination, sensory structures and hierarchies in nematode behavior in pheromones, receptors and host induced stimuli in communications systems.

Unit 2: Genetics of nematode parasitism. Anatomy and ultra structure of plant responses**.**

Unit 3: Plant deferens and incompatibility. Interactions with fungi, bacteria, mycorrhiza, other nematodes, insects and molecular basis of nematode transmission of viruses.

Block 3- Novel concepts in the management of plant parasitic nematode

Unit 1: Nematodes as model systems to study biologicalageing, nutrition, toxic environmental contaminations and cell motility.

Unit 2: Breeding for nematode race specific resistance through biotechnological and genetic engineering techniques.

Unit- 3: Novel concepts in nematode management –inhibition of steroid / hormone metabolism, exploring sensory stimuli, biological activity and mode of action of Avermectins. Modeling and computer simulations in integrated nematode management programmes**.**

Practical

Mechanism and genetic basis of plant resistance. Breeding for nematode race specific resistance through biotechnological and genetic engineering techniques-recombinant DNA (gene silencing); somatic hybridization and protoplast fusion. Novel concepts in nematode management –inhibition of steroid/hormone metabolism, exploring sensory stimuli, biological activity and mode of action of Avermectins. Identification of indigenous bio-control agents, their mass production and distribution. Modelling and computer simulations in integrated pest management programmes. Internet tools and application in Nematology.

Reference

- DROPKIN, V. H., 1980, An Introduction to Plant Nematology, John Wiley & Sons. New York.
- MAGGENTI, A. R., 1981, General Nematology, Springer-Verlag, New York.
- PERRY, R. N. AND MOENS, M., 2013, Plant Nematology. 2nd Ed. CABI Publishing. Willingford, UK
- SIKORA, R. A., COYNE, D., HALLMAN, J. AND TIMPER, P., 2018, Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. 3rdedn. CABI Publishing, England.
- THORNE, G., 1961, Principles of Nematology, McGraw Hill, New Delhi.

- Study of leaf production and supply chain management;
- Risk management/ non cash management in sericulture;
- Visit to grainage and CRC;
- Case studies: chawki rearing unit and silk cocoon production;
- Case study: silkworm seed production unit;
- Case studies: filature and cottage basin units;
- Case studies: charaka unit and improved Charaka units;
- Visit to seed cocoon markets;
- Visit to silk reeling units.

References

- ANONYMOUS., 2002, *Silk Weaving*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- ANONYMOUS., 2002, *Colours from Nature – Silk Dyeing Using Natural Dyes.* Vol. I and II, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- BERNARD, P. AND CORBMAN., 1983, *Textiles: Fiber to Fabric*. 6th Edition, Mc. Graw-Hill International Editions, Home Economic Series, Singapore, p. 594.
- CHARLES, J. HUBER., 1929, *The Raw Silk Industry of Japan*. The Silk Association of America, Inc., New York.
- DANDIN, S. B. AND GUPTA, V. P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
- DANDIN, S. B., JAYANT JAYASWAL. AND GIRIDHAR, K., (Eds.)., 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore.
- DATTA, R. K., 1996, *Global Silk Scenario–2001. Proceedings of the International Conference on Sericulture – 1994.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- GOVINDAN, R., CHINNASWAMY, K. P., KRISHNAPRASAD, N. K. AND REDDY, D. N. R., 2000, *Non-Mulberry Sericulture,*

Silk Technology and Sericulture Economics and Extension. Vol. 3—Proceedingsof NSTS–1999, UAS, Bangalore.

- SINHA, S., 1990, *The Development of Indian Silk*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- TRIPURARI SHARAN., 1984, *Sericulture and Silk Industry*. Published by Y.K. Sharma, Consortium on Rural Technology, Delhi.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – Published by NASSI, Bangalore.
- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.
- *Current Science* – C.V. Raman Institute of Science, Bangalore.
- *Reshme Krishi* (Kannada) – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in
- www.csrtimys.res.in

SER: 610 POST SILK REELING TECHNOLOGY (2+0)

Objective

The course is aimed at emphasizing on post reeling techniques for the production of quality silk fabrics.

Theory

Block 1.Preparatory silk weaving

Unit 1: Silk throwing- soaking and drying, winding, doubling, twisting-types of twisting. Steam setting of twisted yarn. Warping, types of warping with different nature of fibres and yarn winding.

Unit 2: Degumming of silk; Methods of degumming, effect of temperature, time of dipping and equipment's used for degumming. Wet processing- sources and quality of water. Bleaching and dyeing, classification of dyes, factors influencing dyeing, preparation of dyes and methods of dyeing.

Block 2. Silk Weaving

Unit 1: Weaving-loom and its structure, different types of looms-plain loom, semi-automatic loom, automatic loom and shuttleless loom. Types of shuttles, speed of shuttle. Arrangement of yarn for simple weaving and design weaving. Visit to cottage-weaving units.

Unit 2: Printing and methods of printing -block and screen printing, Textile Designing, Motifs for weaving and textile printing, silk/fabric finishing, silk knitting. Disposal of effluents.

References

- ARNOLD, W., 2020, *Theory of Silk Weaving: A Treatise on the Construction and Application of Weaves, and Decomposition and Calculation of Silk Fabrics.* Hansebooks, India. P-108.
- EIRI BOARD, 2008, *Modern Technology of Bleaching, Dyeing, Printing and Finishing of Textiles*. Engineers India Research Institute,P-331.
- MAHADEVAPPA, D., HALLIYAL, V. G., SHANKAR, D. G. AND BHANDIWAD, R., 2000, *Mulberry Silk Reeling Technology.* Oxford and IBH Publishing Co. Pvt. Ltd., P-234.
- MURUGESH BABU, K., 2018, *Silk: Processing Properties and Applications* (2nd Edition). Elsevier,P-272.
- SONWALKAR AND TAMMANNA, N., 1993, *Handbook of Silk Technology,* New Age International (P) Ltd., P-336.

Ph.D. in Soil Science

Course Code	Course Title	Credit Hours
SSC 601	Recent trends in soil physics	2 (2+0)
SSC 602	Modern concept in soil fertility	2 (2+0)
SSC 603	Physical chemistry of soil	2 (2+0)
SSC 604	Soil genesis and micro morphology	2 (2+0)
SSC 605	Bio-chemistry of soil organic matter	2 (2+0)
SSC 606	Soil resource management	3 (3+0)
SSC 607	Modeling of soil plant system	2 (2+0)
SSC 608	Clay Mineralogy	3 (2+1)
SSC 609	Recent trends in soil microbial biodiversity	3 (2+1)
	Total	**21 (19+2)**
SSC 680	Qualifying Examination	3 (0+3)
SSC 681	Seminar -I	1 (0+1)
SSC 682	Seminar - II	1 (0+1)
SSC 683	Teaching Assistantship -I	1 (0+1)
SSC 684	Teaching Assistantship - II	1 (0+1)
SSC 691	Research -I	18 (0+18)
SSC 692	Research -II	18 (0+18)
SSC 693	Research -III	18 (0+18)
SSC 694	Research -IV	18 (0+18)

SSC 601 RECENT TRENDS IN SOIL PHYSICS (2+0)

Objective

To impart knowledge in soil and water interactions, soil aeration, soil crust –clod formation, solar terrestrial and radiation measurement.

Theory

Block I

Unit 1: Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil

water and entropy of the system, soil-plant-atmospheric continuum (SPAC).

Unit 2: Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow.

Unit 3: Theories of horizontal and vertical infiltration under different boundary conditions.

Unit 4: Movement of salts in soils, models formiscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

Block II

Unit 1: Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil; Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.

Unit 2: Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture.

Unit 3: Solar and terrestrial radiation measurement, dissipation and distribution in soil- crop systems; prediction of evapo transpiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra- red thermometer.

References

- ARUNA KUMAR SAHA - Text book of Soil Physics
- RATHANLAL & MANOJ SHUKLA - Principles of Soil Physics
- DILIP KUMAR DAS - Introductory Soil Science
- ISSS, New Delhi - Fundamentals of Soil Science
- DANIEL HILLEL - Introduction to Soil Physics

SSC602 MODERN CONCEPT IN SOIL FERTILITY (2+0)

Objective

To study the nutrient availability, uptake mechanisms, chemical equilibrium, concept of soil fertility evaluation and interpretation for better plant growth and development.

Theory

Block I

Unit1: Nutrient availability – concept and relationships, modern concepts of nutrients availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices.

Unit 2: Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micro nutrients in soils.

Unit 3: Chemical equilibria (including solid-solution equilbria) involving nutrients in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit 4: Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

Block II

Unit 1: Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

Unit 2: Monitoring physical, chemical and biological changes in soils; permanent manorial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit 3: Carbon-a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.

References

- ISSS, New Delhi - Fundamentals of Soil Science
- DILIP KUMAR DAS - Introductory Soil Science
- T. D. BIWAS AND S. K. MUKARJEE - Text book of Soil Science
- JADEJA, HIRPARA , VEKARIA AND SAKARVADIA - Soil Fertilizers and Nutrient Management
- BOYD ELLIS AND HENRY FOTH - Soil Fertility

SSC 603 PHYSICAL CHEMISTRY OF SOIL (2+0)

Objective

To study the colloidal chemistry of soil, predictive approaches, thermo dynamics, adsorption/desorption isotherms and common solubility equilibria in soils.

Theory

Block I

Unit 1: Colloidal chemistry of inorganic and organic components of soils-their formation, clay organic interaction.

Unit 2: Predictive approaches, for, cationexchange equilibria-thermodynamics, empirical and diffuse double layer theory (DDL)-relationships among different selectivity coefficients; structure and properties of diffuse double layer.

Unit 3: Thermodynamics of nutrient transformations in soils; Climate change effects on mineralogy and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.

Blockb II

Unit 1: Adsorption/desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

Unit 2: Common solubility equilibria-carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

References

- KIM H TAN - Principles of Soil Chemistry
- ISSS, New Delhi - Fundamentals of Soil Science
- D.K. DAS - Introductory Soil Science
- L. BATTACHARYA - Text book of Soil Chemistry
- BRADDY, N. C. - Nature and Properties of Soil

SSC 604 SOIL GENESIS AND MICRO MORPHOLOGY (2+0)

Objective

To impart knowledge on pedogenic evolution of soils, weathering, factors affecting soil formation, profile development and mirco pedological features of soils.

Theory

Block I

Unit 1: Pedogenic evolution of soils; soil composition and characterization.

Unit 2: Weathering and soil formation–factors and pedogenic processes; stability and weathering sequences of minerals.

Block II

Unit 1: Assessment of soil profile development by mineralogical and chemical analysis.

Unit 2: Micro-pedological features of soils–their structure, fabric analysis, roleingenesis and classification.

References

- J. SEHGAL - A Text book of Pedology
- ISSS, New Delhi - Fundamentals of Soil Science
- WILLY - Soil Morphology, Genesis and Classification

- RINGROSE VOASE AND HUMPHREY - Soil Micro Morphology
- SPRINGER - New trends in Soil Micro Morphology

SSC 605 BIO CHEMISTRY OF SOIL ORGANIC MATTER (2+0)

Objective

To study the importance of organic matter in soil biochemistry, humus formation theories, nutrient transformation, functional groups of humic substances and humus pesticide instruction in soil.

Theory

Block I

Unit 1: Organic matter in soils and its maintenance Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration.

Unit 2: Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

Unit 3: Nutrient transformation–N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.

BlockII

Unit 1: Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.

Unit 2: Humus-pesticide interactions in soil, mechanisms.

References

- KYOICHI KUMADA - Chemistry of Soil Organic Matter
- F. J. STEVENSON - Humus Chemistry
- BOLLAG AND STOTZKY - Soil biochemistry
- E. A. PAUL - Soil biochemistry
- K. HAIDER - Soil biochemistry

SSC 606 SOIL RESOURCE MANAGEMENT (3+0)

Objective

To study the relevance of soil resource and sustainable land management, types, factors affecting land degradation, soil conservation, watershed management and agro ecological regions of India.

Theory

Block I

Unit 1: Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, gene reserves, and geogenic source of raw materials; soil as a source and sink of green house gases.

Unit 2: Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

Unit 3: Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diaralands. Management of forest, peat and muck soils.

Block II

Unit 1: Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, water logged and wet lands; land restoration and conservation techniques–erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.

Unit 2: Watershed management-concept, objectives and approach; water harvesting and recycling; flood control in watershed management;

socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.

Unit 3: Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

References

- A. K. KOLAY - Remote Sensing and Assessment of Soil Resource
- YUVA RAJ MUTHURAMAN AND MURNGARAGARAN RAMA SWAMY - A text book on Soil Resource and inventory and Problem Soil Management
- RATANLAL AND SHEWART - Principles of Sustainable Soil Manegement in Agroeco Systems
- ROBERT WHITE - Principles and Practice of Soil Science
- HENRY WANG - Principles of Soil Science

SSC 607 MODELLING OF SOIL PLANT SYSTEM (2+0)

Objective

To create awareness about the concepts of modeling, terms and definition, classification of models, high level computer language and models of spatially heterogenous and nutrient uptake.

Theory

Block I

Unit 1: Introduction, terms and definitions; classification of models; Taylor series; numerical methods of differentiation and integration.

Unit 2: High level computer language: FORTRAN-its commands and usage; testing and evaluation of model.

Unit 3: Description of spatially homogeneous models; K transformation model; nitrogen and phosphorus dynamics in soil.

Block II

Unit 1: Spatially heterogeneous models; equation of continuity; Simulation of water flow through soil; Explicit and Explicit-Implicit method; simulation of solute movement through soil with variable moisture flux by explicit-implicit method.

Unit 2: Nutrient uptake model: Integration of nutrient movement in soil (mass flow and diffusion) and uptake by plants (Michaelis-Menten kinetics); Nutrient uptake model: Solubility and free ion activity model.

References

- Plant System - ROLF NIEDER AND BENBI - Hand Book of Processes and Modeling in the Soil
- JOHN HANKS AND RITCHIE - Modeling Plant and Soil System
- MATHEWS & STEPHENS - Crop – Soil Simulation Models
- Advance in Crop Modeling for a Sustainable Agriculture - KENNETH BOOTE

SSC 608 CLAY MINERALOGY (2+1)

Objective

To teach the definitions of clay minerals concepts, crystallography, classification of silicate minerals, interstratified clay mineral, genesis and transformation and surface chemistry of clay minerals.

Theory

Block I

Unit 1: Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations, crystal systems.

Unit 2: Structures and classification of silicate minerals, basics of phyllo silicates, laws governing structural characteristics of phyllo silicates, Gold schmitdt's laws – Laws I and Law II, Classification of Phyllo silicates.

Unit 3: Kaolonite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins.

Unit 4: Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann-Marshal-Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils.

Unit 5: Micas: occurrence and origin in soils, poly types of micas, structure and formation of muscovites and illite.

Unit 6: Vermiculites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite.

Block II

Unit 1: Chlorite: occurrence and structure of chlorites, "swelling chlorites", formation of chlorite.

Unit 2: Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties.

Unit 3: Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

Unit 4: Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

Unit 5: Surface chemistry of clay minerals, clay-organic complexes, nano clay mineralogy.

Unit 6: Clay minerals in different soil orders, role of clay minerals in soil fertility management.

Practical

- Separation of clay for mineralogical study
- X-ray diffraction analysis of clay
- Selective dissolution of clay minerals
- IR, DTA and SEM of clay minerals
- Identification and quantification of clay minerals

- Determination of surface charge of clay minerals
- Potentiometric titration of clay minerals.

References

- VELDEVELDEVELDE - Introduction to Clay Minerals
- LIMA R. WESLEY - Clays and Minerals
- MURRAY - Applied Clay Minerals
- ADA SWINEFORD - Clay and Clay minerals
- BRUCE VELDE - Origin and Mineralogy of Clay
- SPRINGER - The Origin of Clay Minerals in Soil and weathered rocks

SSC 609 RECENT TRENDS IN SOIL MICROBIAL BIODIVERSITY (2+1)

Objective

To acquaint students with respect to microbial evaluation and biodiversity, qualitative ecology of micro- organisms, nitrogen fixing micro – organisms, serology and molecular characterization and bio degradability.

Theory

Block I

Unit 1: Microbial evaluation and biodiversity, Microbial communities in ecosystems, New insights in below ground diverse of plant performance.

Unit 2: Qualitative ecology of microorganisms; Biomass and activities.

Unit 3: Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterizing N fixing microorganisms.

Block II

Unit 1: Serology and molecular characterization, ecological aspects

of bio determination, soil waste and water management

Unit 2: Bio degradability, testing and monitoring of the bioremediation of pollutants and bacterial fertilizers.

Practicals

- Determination of soil microbes using classical techniques.
- Determination of soil microbial diversity using molecular techniques.
- Estimation of soil microbial biomass carbon, nitrogen and phosphorus.
- Estimation of key soil enzyme activities.
- Community level physiological profiling of microbial diversity.

References

- SPRINGER - Advances in Soil Microbiology, Resent Trends and future Prospects
- PRASADA BABU AND PARAMAGEETHAM CHINTHALA - Resent Trends in Microbial Diversity and Bio Prospecting
- ASHASINHA AND SEWETA SRIVASTAVA - Microbial Biodiversity
- ELSAS, JANSON AND TRERORS - Models Soil Microbiology