UNIVERSITY OF CALCUTTA

Notification No. CSR/ 18 /2013

It is notified for the information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 01.08.2013, approved the **Curricula and Revised Syllabi for the Master Degree Programmes in Agricultural Science** to be imparted in the Institute of Agricultural Science, under this University, as laid down in the accompanying pamphlet.

The above will take immediate effect.

05.08.2013

(Prof. Basab Chaudhuri)

Registrar

SENATE HOUSE
KOLKATA-700073
The 5th August, 2013

CURRICULA AND REVISED SYLLABI FOR MASTER DEGREE PROGRAMMES IN AGRICULTURAL SCIENCES 2013

Agricultural Chemistry and Soil Science, Agronomy, Genetics and Plant Breeding, Horticulture, Plant Physiology and Seed Science and Technology

INSTITUTE OF AGRICULTURAL SCIENCE

CALCUTTA UNIVERSITY

51/2 HAZRA ROAD KOLKATA – 700019

CONTENTS

INTRODUCTION

The Calcutta University, a premier centre of learning in the country, is imparting formal agricultural education and pursuing agricultural research since more than five decades, also responded adequately to the changes in this field to be with the main stream of agricultural education and research in the country.

The course-credit system is now being introduced as a system of teaching in modernizing agricultural education, extension and research. This would offer continuous evaluation of students, high degree of student-teachers interaction and higher order of flexibility in introducing new course curriculum. The present revised syllabus closely corroborates with the recommended syllabus of ICAR (2009-10).

REGULATION FOR M.Sc (Ag) EXAMINATION

The examination for the degree of Master of Science in Agriculture in the following six disciplines viz- (i) Agricultural chemistry and soil science, (ii) Agronomy, (iii) Genetics and Plant Breeding, (iv) Horticulture, (v) Plant physiology and (vi) Seed Science and Technology shall be held in four semesters:

Course

The course in each Department are calssified into three groups:

A. 1 Core Courses…….. 25 credits
A. 2 Minor Courses ……..…….. 9 credits
B. Supportive Course …… 5 credits
C. Seminar ……..……. 1 credit
D. Dissertation ……... 20 credits

Total 60 credits

One credit means one lecture per week. Thus, 2+1 or 2+0 would indicate two theory classes and one practical class or only two theory classes in a week respectively. In each course with practical or without practical, Marks will be 100. Marks distribution of a course is given as under.

a. With Practical

	Marks
Theory ……..……	60
Practical …….……..……	40
Total	100

Marks Distribution

	Quiz / Internal Assessment		End term Examination	Total
Theory	**2 x 5 = 10**	**+**	**50**	**60**
Practical	**10**	**+**	**30**	**40**

b. Without Practical

Marks

Theory……100

Marks Distribution

Theory	Quiz		End Term Examination	Total
	4 x 10 = 40	+	60	100

At the end term examination a theoretical paper or either 50 or 60 marks and a practical paper or 30 marks shall be of 3 hours' duration.

Award of grades :

10 points grade system will be followed. On the basis of the results of each course, grade will be given according to the following computation. For example, if a student scores 75% in theory and 68%in practical in a 3 credit course (2+1) his /her grade point for the course will be as follows :

$$\text{Grade point} = \frac{2 \times 75 + 68 \times 1}{3 \times 10} = 7.26$$

Average grade point for a semester :

The computation of average grade point of a student in a semester will be worked out as follows :

Example :

1st Semester

Course	Credit	Grade Scored
1	2 + 1	8.88
2	2 + 1	8.00
3	2 + 0	7.40
4	2 + 1	8.62
5	3 + 1	6.95

Average grade point = * 7.94

$$\textbf{Average Grade point} = \frac{(8.88 \times 3) + (8.00 \times 3) + (7.40 \times 2) + (8.62 \times 3) + (6.95 \times 4)}{15} = *7.94$$

Cumulative grade point average over four semesters :

Working out simple average, cumulative grade point average will be obtained over four semesters.

Significance of grades :

On the basis of the cumulative results of the student's performance the following grades will be given in each semester as well as over four semesters.

Numerical Grade points	**Grades**	
8.00 -- 10.00	Excellent	(A)
7.00 – 7.99	Good	(B)
6.00 – 6.99	Fair	(C)
5.00 – 5.99	Satisfactory	(D)
Below – 5.00	Fail	(F)

Repeat:

If a student gets 'F' in a particular course, he/she shall be deemed to have failed in that course only and shall be required to repeat that course in a subsequent semester when offered. A student shall repeat the course in which he/she fails upto a maximum of two times. If the student fails to clear the repeat even after two times, he/she shall be dropped from the rolls of the University on the advice of the concerned Dean of the Faculty.

Re-admission

If a student fails to clear the repeat and dropped from the university roll, he/she may apply for re-admission in the beginning of the next academic session and he/she shall be considered for admission along with the fresh candidates on the basis of merit.

1. Agricultural Chemistry and Soil Science

1st Semester

Major	ACS 503*	Soil Chemistry	2+1
	ACS 504*	Soil Mineralogy, genesis, classification and survey	2+1
	ACS 506*	Soil Biology and Biochemistry	2+1
Minor	AGRO 501	Modern concept of Crop Production	3+0

Total: 9 +3 = 12 credits

2nd Semester

Major	ACS 501*	Soil Physics	2+1
ACS 502*	Soil fertility and Fertilizer use		2+1
	ACS 513	Management of problematic soils and water	1+0
	ACS 511	Analytical techniques and instrumental methods in soil and plant analysis	1+2
Supportive	SPC 599	Basic Statistics and Experimental Design	1+2

Total: 7 + 6 = 13 credits

3rd Semester

Major	ACS 509	Soil and water pollution	2+1
	ACS 505	Soil erosion and Conservation	2+1
Minor	PPY 506	Physiology of growth and yield and modelling	2+1
	PPY 511	Mineral Nutrition	2+1

Total: 12 credits

4th Semester

Supportive	SPC 598	Principles of Crop Protection	1+1
	SPC 592	Seminar	1
	SPC 593	Dissertation	20

Total: 23 credits

Total credits = 60

AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

Major Courses	**Course Title**	**Credit**
ACS 501*	Soil Physics	2 + 1
ACS 502*	Soil Fertility and Fertilizer Use	2 + 1
ACS 503*	Soil Chemistry	2 + 1
ACS 504* and Survey	Soil Mineralogy, Genesis, Classification	2 + 1
ACS 506*	Soil Biology and Biochemistry	2 + 1
ACS 509	Soil and water pollution	2 + 1
ACS 505	Soil erosion and Conservation	3 + 0
ACS 511	Analytical Techniques and Instrumental Methods in Soil and Plant Analysis	1 + 2
ACS 513	Management of Problematic soil and water	1 + 0

Minor Courses

PPY 506	Physiology of growth and yield and modelling	2 + 1
PPY 511	Mineral Nutrition	2 + 1
AGRO 501	Modern Concepts of Crop Protection	3 + 0

Supporting Courses

SPC 599	Basic Statistics and Experimental Design	1 + 2
SPC 598	Principles of Crop Protection	1 + 1

ACS 501 Soil Physics 2+1

Objective
To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory
Scope of soil physics and its relation with other branches of soil science; soil as a three phase system. Soil texture, textural classes, mechanical analysis, specific surface. Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage –basic concepts. Soil structure – genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, conservation tillage, characteristics of good soil tilth; soil crusting – mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties, clod formation. 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. Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity in saturated and unsaturated soils. Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum. Composition of soil air; renewal of soil air – convective flow and diffusion; measurement of soil aeration requirement for plant growth; soil air management. 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. Soil physical environment in relation to plant growth.

Practical
- Mechanical analysis by pipette and international methods\
- Aggregate analysis – dry and wet and determination of some physical constants by Keen and Raczkowski Box
- 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
- Soil temperature measurements by different methods
- Estimation of water balance components in bare and cropped fields

ACS 502 Soil fertility and Fertilizer use 2+1

Objective
To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory
Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients – functions and deficiency symptoms. Bulky and concentrated organic manures, their composition, characteristics, transformation in soil and their effect on soil productivity. Role of manures in sustainable agriculture, Enriched compost preparation, Effect of manures on soil properties, Long term effect of

FYM, vermin compost and rural as well as urban compost, Bulky and concentrated manures and their effect on soil properties. Soil and fertilizer nitrogen, phosphorus, potassium and sulphur fertilizers: sources, forms and behavior in soil. Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability. Soil testing and fertilizer recommendation; soil test crop response correlations and response functions. Fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site –specific nutrient management; plant need based nutrient management. Soil fertility evaluation – biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

- Identification of N,P,K and micronutrient fertilizers
- Determination of organic carbon from soils
- Chemical analysis of soil for total and available nutrients
- Analysis of plants and manures for essential elements

ACS 503 Soil Chemistry 2 + 1

Objective

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth

Theory

Chemical (elemental) composition of the earth's crust and soils. 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; soil organic matter – fractionation of soil organic matter and different fractions, clay-organic interactions. Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, jenny's concept). AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition. Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects. Adsorption/desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and nonselective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system). Chemistry and electro-chemistry of submerged soils.

Practical

- Determination of CEC exchangeable cations , and AEC of soils
- Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter
- Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method
- Determination on titratable acidity of an acid soil by $BaCl_2$-TEA method and determination of exchangeable Al and H
- Determination of lime requirement of an acid soil by buffer method
- Determination of gypsum requirement of an alkali soil

ACS 504 Soil Mineralogy, Genesis, Classification and Survey 2 + 1

Objective
To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory
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. Factors of soil formation, climatogenic soil, soil formation models, soil forming processes; weathering of rocks and mineral transformations soil profile; weathering sequences of minerals with special reference to Indian soils. 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. Soil survey and its types; soil survey techniques – conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlation; soil survey interpretations; soil mapping units, techniques for generation of soil maps. Landform – soil relationship; major soil groups of India and West Bengal; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem. Remote sensing: Concept and its application in soil resource inventory.

Practical
- Identification of rocks and minerals
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Na_2Co_3 fusion for determination of inorganic constituents of soil
- Calculation of weathering indices and its application in soil formation.
- Grouping soils using available data interpretation for soil and land use.
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales.
- Land use planning exercises using conventional and Remote sensing tools.
- Interpretation of satellite imagery, Aerial photography.

ACS 506 Soil Biology and Biochemistry 2 + 1

Objective
To teach students the basis of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory
Soil biota and characterisation, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. Microbial transformations of carbon, nitrogen, phosphorus, sulphur,

iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, biochemistry of humus formation, functional groups, adsorption by soil clay, metal humus interaction, humus formation; cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers – definition, scope, classification, specifications, method of production and role in crop production. Constraint in application of biofertilizers.

Practical

- Determination of soil microbial population.
- Soil microbial biomass.
- Elemental composition, fractionation of organic matter and functional groups and their identification by electrometry and viscometry methods, IR spectroscopy.
- Decomposition of organic matter in soil.
- Soil enzymes.
- Measurement of important soil microbial processes such as ammonification, nitrification, N_2 fixations, S oxidation, P solubilization and mineralization of other micro nutrients.
- Study of rhizosphere effect.
- Staining of bacteria.
- Biochemical tests of bacteria.

ACS 509 Soil and water pollution 2 + 1

Objective

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

Soi and water pollution problems associated with agriculture, nature and extent. Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides and other agrochemicals including herbicides, acid rains, oil spills etc.; water and soil pollutants –their CPC standards and effect on plants, animals and human beings. Sewage and industrial effluents – their composition and effect on soil properties/ health and plant growth and human beings; soil as sink for waste disposal. Heavy metal pollutrion in soils, Pollution of water resources due to leaching of nutrients and pesticides from soil; arsenic, chloride and fluoride pollution in waters, emission of green house gases – carbon dioxide, methane and nitrous oxide. 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
- Determination of pH, EC and SAR of soils and waters
- Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in contaminated soils.
- Heavy metals in contaminated soils and plants, determination of free CO_2 from the effluent water
- Management of contaminants in soil and plants to safeguard food safety

- Visit to various industrial sites to study the impact of pollutants on soil and plants.

ACS 505 Soil Erosion and Conservation 2+1

Theory

History, distribution, identification and description of soil erosion problems in India and West Bengal. 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 runoff; soil losses in relation to soil properties and precipitation. Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country and West Bengal.

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands with particular reference to West Bengal

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds with special reference to West Bengal; use of remote sensing in assessment and planning of watersheds.

Practical

- Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI_{30}) using rain gauge data
- Visits to watersheds of the state

ACS 511 Analytical Techniques and Instrumental Methods in Soil and Plant Analysis 1 +2

Objective

To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Theory and Practical

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling. Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils. Principles of visible and ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X-ray by different methods. Determination of cation and anion exchange capacities of soils; estimation of

exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant samples by wet digesting and dry ashing and soil by wet digestion methods. Determination of lime and gypsum requirement of soil. Analysis of soil extracts and irrigation waters for their soluble cations and anions and interpretation of results.

ACS 513 Management of Problem soils and waters 1+ 0

Objective
To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

Theory
Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible. Morphological features of saline-sodic soils; characterization of salt affected soils – soluble salts, ESP, pH; physical, chemical and microbiological properties. Management of salt affected soils; salt tolerance of crops – mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic, calcareous and dry land soils. Acid soils – nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management. Management of forest , range and perennial marshy lands with particular reference to West Bengal. Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality. Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

SPC 598 Principles of crop protection 1+1

Objective
To familiarize the students about the pests, pesticides and methods of pest control.

Theory
Concept, nomenclature and distribution of pests. History, concept and methods of pest control.
Principles of pest control. Pesticide classification based on use, chemistry and target. Mode and mechanisms of action of pesticide. Fate and persistence of pesticides in environment. Pesticide active ingredient, formulation, adjuvant and sefeners. Pesticide application techniques, equipments and accessories. Pest management in important field and horticultural crops and cropping system. Concept and application of Integrated Pest Management

Practical
Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops. Pesticide calculation, residue estimation and determination of LD_{50} value. Symptoms and management of diseases of different vegetable crops.

SPC 599 Basic Statistics and Experimental Design 1+2

Theory

Meaning and scope of statistics, collection, scrutiny and presentation of data. Frequency distribution and diagrammatic representation. Measures of central tendency – mean, mode, median. Measures of dispersion – range , quartile deviation, mean deviation standard deviation, relative dispersions. Concept and measurement of skewness and kurtosis. Bivariate data and their summarization, scatter diagram, correlation, linear and non-linear regression. Elementary probability theory and normal distribution. Population and sample, parameter and statistics, sampling distribution of statistics and its standard error. Method of sampling – random, stratified, systematic and multistage. Test of significance – one sample and two sample problems, X^2 test for homogeneity, independence and goodness of fit, test for correlations and regression coefficient.

Practical

Application, layout and analysis of data of principle experimental designs – randomized blocks, latin squares, complete randomized design, split plot, strip plot. Methods of analysis and uses of combined experiments, group of experiments, missing plot techniques. Transformation of data, factorial experiments, concept of mean effect and interaction, concept of confounding. Fitting of curvilinear regressions. Sampling in field experiments and experiments on cultivator's fields. Use of computer in statistical analysis.

2. Agronomy

1st Semester

Major	AGRON 501*	Modern concept in crop production	3+0
	AGRON 502*	Principles and practices of soil fertility and nutrient management	2+1
	AGRON 503*	Principles and practices of weed management	2+1
Minor	SST 501	Principles of seed production	3+0

Total: 12 credits

2nd Semester

Major	AGRON 506	Agronomy of major cereals and pulses	2+0
	AGRON 504*	Principles and practices of water management	2+1
	AGRON 511	Cropping system	2+0
	AGRON 512	Dryland farming	2+1
Supportive	SPC 599	Basic Statistics and Experimental Design	1+2

Total: 13 credits

3rd Semester

Major	AGRON 507	Agronomy of oilseed, fibre and sugar crops	2+1
	AGRON 513	Principles and practices of organic farming	2+1
Minor	PPY 506	Physiology of growth and yield and modelling	2+1
	HOR 501	Propagation and nursery management in Horticultural crops	2+1

Total: 12 credits

4th Semester

Supportive	SPC 598	Principles of Crop Protection	1+1
	AGRON 592	Seminar	1
	AGRON 593	Dissertation	20

Total: 23 credits

Total credits = 60

Major Courses	**Course Title**	**Credit**
AGRON 501*	Modern concept in crop production	3+0
AGRON 502*	Principles and practices of soil fertility and nutrient management	2+1
AGRON 503*	Principles and practices of weed management	2+1
AGRON 504*	Principles and practices of water management	2+1
AGRON 506	Agronomy of major cereals and pulses	2+0
AGRON 507	Agronomy of oilseed, fibre and sugar crops	2+1
AGRON 511	Cropping system	2+0
AGRON 512	Dryland farming	2+1
AGRON 513	Principles and practices of organic farming	2+1
Minor Courses		
SST 501	Principles of seed production	3+0
PPY 506	Physiology of growth and yield and modelling	2+1
HOR 501	Propagation and nursery management in Horticultural crops	2+1
Supportive Course		
SPC 599	Basic Statistics and Experimental Design	1+2
SPC 598	Principles of Crop Protection	1+1

AGRON 501 Modern concept in crop production 3+0

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

Theory
Crop growth analysis in relation to environment; agro-ecological zones of India. Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit. 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. Scientific principles of crop production; crop response production functions; concept of soil- plant relations; yield and environmental stress. 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.

AGRON 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 apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory
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. Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients. Preparation and use of farmyard manures, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions. Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; use of vermin compost and residue wastes in crops

Practical
- Determination of soil pH, EC, organic C, total N, available N, P, K and S in soils
- Determination of total N, P, K and S in plants
- Interpretation of interaction effects and computation of economic and yield optima

AGRON 503 Principles and practices of weed management 2+1

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

Theory
Weed biology and ecology, crop – weed competition including allelopathy; – principles and methods of weed control and classification; weed indices. Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides. Herbicide structure – activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures; herbicide resistance and management; weed control through bio-herbicides, myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; herbicide resistance in weeds and crops; herbicide rotation. Weed management in major crops, cropping systems parasitic weeds; weed shifts in cropping systems; aquatic and perennial weed control. Integrated weed management; cost; benefit analysis of weed management.

Practical
- Identification of important weeds of different crops
- Preparation of weed herbarium
- Weed survey in crops and cropping systems
- Crop - weed competition studies
- Calibration of sprayers
- Calculation of herbicide requirements
- Use of various types of spray pumps and nozzles
- Preparation of spray solutions and application of herbicides
- Herbicide residue bioassay
- Studies on allelopathic influence of various crops and weeds
- Planning and execution of weed control experiments

AGRON 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
Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states. Soil 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. Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; microirrigation system; fertigation; management of water in controlled environments and polyhouses. Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency. 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.

Practical

- Measurement of soil water potential by using tensiometer, and pressure plate and apparatus
- Soil-moisture characteristics curves
- Water flow measurements using different devices
- Determination of irrigation requirements
- Calculation of irrigation efficiency
- Determination of infiltration rate
- Determination of saturated/unsaturated hydraulic conductivity

AGRON 506 Agronomy of major cereals and pulses 2+0

Objective

To teach the crop husbandry of cereals and pulse crops.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production**,** value addition and agro-based industries of:

Rabi cereals.
Kharif cereals.
Rabi pulses.
Kharif pulses.

AGRON 507 Agronomy of oilseed, fibre and sugar crops 2+1

Objective

To teach the crop husbandry of oilseed, fiber and sugar crops.

Theory

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

Rabi oilseeds – Rapeseed and mustard, linseed, etc.
Kharif oilseeds - Groundnut, sesame, castor, sunflower, soybean etc.
Fiber crops - Cotton, jute, sunhemp etc.
Sugar crops – Sugar-beet and sugarcane.

Practical

- Planning and layout of field experiments
- Cutting of sugarcane sets, its treatment and methods of sowing, tying 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, visit to a sugarcane research station
- Intercultural operations in different crops
- Working out growth indices (CGR, RGR, NAR, LAD, LER) aggressiveness, relative crowding coefficient, monetary yield advantage and ATER (Area Time Equivalent Ratio) of prominent intercropping systems of different crops
- 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 fibre of different fibre crops
- Study of seed production techniques in various 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

AGRON 511 Cropping system 2+0

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

Theory
Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use. Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems. Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture. 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. Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

AGRON 512 Dryland farming 2+1

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

Theory

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture. Extent of dryland area in India, agencies and programmes of dryland agriculture in India. 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. Stress physiology and crop 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. 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; types and their mode of action; soil and crop management techniques, seeding and efficient fertilizer use, steps to enhance water use efficiency of dry land crops. Concept of watershed resource management, problems, approach and components, classification, codification, objectives, strategies, case studies in dry farming situation.

Practical

Seed treatment, seed germination and crop establishment in relation to soil moisture contents Moisture stress effects and recovery behaviour of important crops. Estimation of moisture index and aridity index. Spray of anti-transpirants and their effect on crops. Collection an interpretation of data for water balance equations. Water use efficiency. Preparation of crop plans for different drought conditions. Study of field experiments relevant to dryland farming. Visit to dryland research stations and watershed projects

AGRON 513 Principles and practices of organic farming 2+1

Objective

To study the principles and practices of organic farming for sustainable crop production.

Theory

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; land and water management - land use, minimum tillage; shelter zones, hedges, pasture management, agro-forestry. Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermi compost, green manures and biofertilizers. Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity. Control of weeds, diseases and insect pest management, biological agents and pheromones, biopesticides. Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

Aerobic and anaerobic methods of making compost. Making of vermicompost. Identification and nursery raising of important agro-forestry trees 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 an organic farm.Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

SPC 598 Principles of crop protection 1+1

Objective
To familiarize the students about the pests, pesticides and methods of pest control.

Theory
Concept, nomenclature and distribution of pests. History, concept and methods of pest control.
Principles of pest control. Pesticide classification based on use, chemistry and target. Mode and mechanisms of action of pesticide. Fate and persistence of pesticides in environment. Pesticide active ingredient, formulation, adjuvant and sefeners. Pesticide application techniques, equipments and accessories. Pest management in important field and horticultural crops and cropping system. Concept and application of Integrated Pest Management

Practical
Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops. Pesticide calculation, residue estimation and determination of LD_{50} value. Symptoms and management of diseases of different vegetable crops.

SPC 599 Basic Statistics and Experimental Design 1+2

Theory
Meaning and scope of statistics, collection, scrutiny and presentation of data. Frequency distribution and diagrammatic representation. Measures of central tendency – mean, mode, median. Measures of dispersion – range , quartile deviation, mean deviation standard deviation, relative dispersions. Concept and measurement of skewness and kurtosis. Bivariate data and their summarization, scatter diagram, correlation, linear and non-linear regression. Elementary probability theory and normal distribution. Population and sample, parameter and statistics, sampling distribution of statistics and its standard error. Method of sampling – random, stratified, systematic and multistage. Test of significance – one sample and two sample problems, X^2 test for homogeneity, independence and goodness of fit, test for correlations and regression coefficient.

Practical
Application, layout and analysis of data of principle experimental designs – randomized blocks, latin squares, complete randomized design, split plot, strip plot. Methods of analysis and uses of combined experiments, group of experiments, missing plot techniques. Transformation of data, factorial experiments, concept of mean effect and interaction, concept of confounding. Fitting of curvilinear regressions. Sampling in field experiments and experiments on cultivator's fields. Use of computer in statistical analysis.

3. Genetics and Plant Breeding

1st Semester

Major	GPB 501	Principles of Genetics	2+1
	GPB 502	Principles of Cytogenetics	2+1
	GPB 503	Principles of Plant Breeding	2+1
Minor	SST 501	Principles of seed production	3+0

			Total: 12 credits

2nd Semester

Major	GPB 511	Breeding cereal, forages and tea	2+0
	GPB 509	Biotechnology for crop improvement	1+1
Minor	ACS 511	Analytical techniques and instrumental methods in soil and plant analysis	1+2
	PPY 508	Morphogenesis, tissue culture and transformation	2+1
Supportive	SPC 599	Basic Statistics and Experimental Design	1+2

			Total: 13 credits

3rd Semester

Major	GPB 508	Cell Biology and Molecular Genetics	2+1
	GPB 504*	Principles of Quantitative Genetics	2+1
	GPB 512	Breeding legume, oilseed and fibre crop	2+0
	GPB 601	Plant Genetic Resources Conservation and IPR	2+1
	GPB 505	Breeding for biotic and abiotic stress	1+0

			Total: 12 credits

4th Semester

Supportive	SPC 598	Principles of Crop Protection	1+1
	GPB 592	Seminar	1
	GPB 593	Dissertation	20

			Total: 23 credits

Total credits = 60

Major Courses	**Course Title**	**Credit**
GPB 501*	Principles of Genetics	2+1
GPB 502*	Principles of Cytogenetics	2+1
GPB 503*	Principles of Plant Breeding	2+1
GPB 504*	Principles of Quantitative Genetics	2+1
GPB 505	Breeding for biotic and abiotic stress	1+0
GPB 508	Cell Biology and Molecular Genetics	2+1
GPB 509	Biotechnology for crop improvement	1+1
GPB 511	Breeding cereal, forages and tea	2+0
GPB 512	Breeding legume, oilseed and fibre crop	2+1
GPB 601	Plant Genetic Resources Conservation and IPR	2+1
Minor Courses		
SST 501	Principles of seed production	3+0
PPY 508	Morphogenesis, tissue culture and transformation	2+1
ACS 511 in soil and plant analysis	Analytical techniques and instrumental methods	1+2
Supportive Course		
SPC 599	Basic Statistics and Experimental Design	1+2
SPC 598	Principles of Crop Protection	1+1

GPB 501 Principles of Genetics 2+1

Objective

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

Theory

Beginning of genetics; Cell structure and cell division; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance. Multiple alleles, Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance. Population - Mendelian population – Random mating population - Frequencies of genes and genotypes - Causes of change: Hardy-Weinberg equilibrium. Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis. Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters. Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing. Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR-based cloning, positional cloning; Nucleic acid hybridization and immuno-chemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs). Genomics and proteomics; Functional and pharmacogenomics; Metagenomics. Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles 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 - Extraction of proteins and isozymes – use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

GPB 502 PRINCIPLES OF CYTOGENETICS 2+1

Objective

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

Theory

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. Chromosomal theory of inheritance – Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over-mechanisms and theories of crossing over-recombination models, cytological basis, Variation in

chromosome structure, Evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding and painting - *in situ* hybridization and various applications. 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 lethals and chromosome complexes. Inter-varietal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids 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. Reversion of autopolyploids to diploids; Genome mapping in polyploids -Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica). Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids – Bridge species. Fertilization barriers in crop plants at pre-and postfertilization levels- *In vitro* techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. Microscopy: various types of microscopes, Observing sections of specimen using Electron microscope; Preparing specimen for observation – Fixative preparation and fixing specimen for light microscopy studies in cereals, Studies on the course of mitosis in wheat, pearl millet, Studies on the course of mitosis in onion and *Aloe vera***,** Studies on the course of meiosis in cereals, millets and pulses, Studies on the course of meiosis in oilseeds and forage crops - Using micrometers and studying the pollen grain size in various crops. Various methods of staining and preparation of temporary and permanent slides. Pollen germination *in vivo* and *in vitro;* Microtomy and steps in microtomy; Agents employed for the induction of various ploidy levels; Solution preparation and application at seed, seedling level; Identification of polyploids in different crops; Induction and identification of haploids; Anther culture and Ovule culture; Morphological observations on synthesized autopolyploids; Observations on C-mitosis, learning on the dynamics of spindle fibre assembly; Morphological observations on allopolyploids; Morphological observations on aneuploids; Cytogenetic analysis of interspecific and intergeneric crosses; Maintenance of Cytogenetic stocks and their importance in crop breeding; Various ploidy levels due to somaclonal variation; Polyploidy in ornamental crops. Fluorescent *in situ* hybridization (FISH) . Genome *in situ* hybridization (GISH).

GPB 503 Principles of Plant Breeding 2+1

Objective

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

Theory

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants - Centres of Origin-biodiversity and its significance. Genetic basis of breeding self- and cross - pollinated crops including mating systems and

response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding. Self-incompatibility and male sterility in crop plants and their commercial exploitation. Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach). Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds. Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection. Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding. Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses. Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant 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. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records;
Learning techniques in hybrid seed production using male-sterility in field crops.

GPB 504 Principles of Quantitative Genetics 2+1

Objective

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

Theory

Mendelian traits *vs* polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects. Principles of Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance. Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models - concepts of selection - heritability and genetic advance. Generation mean analysis; Mating designs - Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for G x E analysis and stability parameters; AMMI analysis – principles and interpretation. QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic

analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II – Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation – Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model – Principal Component Analysis model - Additive and multiplicative model – Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model – Selection systems - Biplots and mapping genotypes.

GPB 505 BREEDING FOR BIOTIC AND ABIOTIC STRESSES 1+0

Objective

To impart knowledge on biotic and abiotic stress condition.

Theory

Breeding for biotic stresses – definition and history, nature of resistance; methods of breeding for disease and insect resistance, scope and application, multiline approach. Breeding for abiotic stress: general consideration, nature of temperature and moisture stresses, nutritional stresses, screening techniques and breeding approaches.

GPB 508 CELL BIOLOGY AND MOLECULAR GENETICS 2+1

Objective

To impart knowledge in theory and practice about cell structure, organelles and their functions, molecules like proteins and nucleic acids.

Theory
Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastids - chloro/ chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes. Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition; Cell division and physiology of cell division. Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors. Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging.

Practical
Morphological and Gram staining of natural bacteria; Cultivation of bacteria in synthetic medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaque assay method; Determination of soluble protein content in a bacterial culture. Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population in lysate; Study of lytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

GPB 509 Biotechnology for crop improvement 1+1

Objective
To impart knowledge and practical skills to use biotechnological tools in crop improvement.

Theory
Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding. Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation. Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F_2s, back crosses, RILs, NILs and DH). Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding. Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs. Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases. Biotechnology applications in male sterility/hybrid breeding, molecular farming. MOs and related issues (risk and regulations); GMO;

International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights. Bioinformatics and Bioinformatics tools. Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit. Transformation using *Agrobacterium* strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

GPB 511 Breeding cereal, forages and tea 2+0

Objective

To provide insight into recent advances in improvement of cereals and forage crops and sugarcane using conventional and modern biotechnological approaches.

Theory

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.* – Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding. Wheat: 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, exploitation of heterosis etc; Sorghum: 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; Pearl millet: 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. Maize: 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 - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectives - yield, quality characters, biotic and abiotic stress resistance etc. Tea: 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 grasses: 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., synthetics, composites and apomixes. Forage legumes: 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. Tree fodders: 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*, palatability studies. Distinguishing features of popular released varieties in Rice and Sorghum -Wheat, Pearl millet, Maize and other millets - Sugarcane, forage grasses and legumes and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.

GPB 512 Breeding legume, oilseed and fibre crop 2+1

Objective

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

Theory

Pigeonpea: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship; Morphological and molecular descriptors used for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc* - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes. Chickpea: Evolution and distribution of species and forms - Wild relatives and germplasm - cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Protein quality improvement; Conventional and modern plant breeding approaches, progress made - Breeding for anti nutritional factors. Other pulses: Greengram, blackgram, fieldpea, lentil,, lathyrus, cowpea, lablab, mothbean: Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them. Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress etc. Rapeseed and Mustard: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc; Oil quality – characteristics in different oils; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship. Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship. Other oilseed crops: Sunflower, sesame, safflower, niger: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements. Castor: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, breeding objectives yield, quality characters, biotic and abiotic stress *etc* - Hybrid breeding in castor – opportunities, constraints and achievements. Cotton: Evolution of cotton; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Development and maintenance of male sterile lines.

Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc; Mesta and minor fibre crops: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic

stress etc. Distinguishing features of the released varieties in pulses, oilseeds and cotton; Maintenance of seed purity and seed production.

Practical
Use of descriptors for cataloguing – Floral biology - emasculation – pollination techniques; Study of range of variation for yield and yield components - Study of segregating populations in Redgram, Greengram, Blackgram and other pulse crops; Attempting crosses between blackgram and greengram. Use of descriptors for cataloguing – Floral biology, emasculation, pollination techniques of oilseed crops like Sesame, Groundnut, Sunflower and Castor, Cotton: Use of descriptors for cataloguing – Floral biology - Learning on the crosses between different species - Cotton: Study of range of variation for yield and yield components - Study of segregating populations - evaluation - Trait based screening for stress resistance - Cotton fibre quality evaluation – conventional and modern approaches; analysing the lint samples of different species, interspecific and interracial derivatives for fibre quality and interpretation – Development and maintenance of male sterile lines Evaluation of cotton cultures of different species for insect and disease resistance – Learning the mechanisms of resistance, quantifying the resistance using various parameters; 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 cotton yarn production, its quality evaluation and uses.

GPB 601 Plant Genetic Resources Conservation and IPR 2+1

Objective
To provide information about collection, evaluation, documentation, maintenance and use of plant genetic resources for crop improvement.

Theory
Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and global pattern of diversity; Basic genetic resources and transgenes. Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation. Germplasm conservation- *in situ*, *ex situ*, and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; Registration of plant genetic resources. PGR data base management; National and international protocols for PGR management; PGR for food and agriculture (PGRFA); PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges; Seed Act, *sui generis* system; Geographical indicators, Intellectual property; Patents, copyrights, trademarks and trade secrets. Journey from wild to domestication; Genetic enhancement- need for genetic enhancement; Genetic enhancement in pre Mendelian era and 21st century; Genetic enhancement and plant breeding; Reasons for failure in genetic enhancement; Utilization of genetic resources, concept of core and mini-core collections, genetic enhancement/Pre-breeding for crop improvement including hybrid development.

Practical
Morphological characteristics of important field crops and identification of taxonomic categories. Identifications – seeds, planting materials, fruits, flower of field crops. Anatomical features of field crops. Preparation of herbarium sheets of field crops. Visit to research centres/ Botanic gardens / Horticultural gardens.

SPC 598 Principles of crop protection 1+1

Objective
To familiarize the students about the pests, pesticides and methods of pest control.

Theory
Concept, nomenclature and distribution of pests. History, concept and methods of pest control.
Principles of pest control. Pesticide classification based on use, chemistry and target. Mode and mechanisms of action of pesticide. Fate and persistence of pesticides in environment. Pesticide active ingredient, formulation, adjuvant and sefeners. Pesticide application techniques, equipments and accessories. Pest management in important field and horticultural crops and cropping system. Concept and application of Integrated Pest Management

Practical
Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops. Pesticide calculation, residue estimation and determination of LD_{50} value. Symptoms and management of diseases of different vegetable crops.

SPC 599 Basic Statistics and Experimental Design 1+2

Theory
Meaning and scope of statistics, collection, scrutiny and presentation of data. Frequency distribution and diagrammatic representation. Measures of central tendency – mean, mode, median. Measures of dispersion – range , quartile deviation, mean deviation standard deviation, relative dispersions. Concept and measurement of skewness and kurtosis. Bivariate data and their summarization, scatter diagram, correlation, linear and non-linear regression. Elementary probability theory and normal distribution. Population and sample, parameter and statistics, sampling distribution of statistics and its standard error. Method of sampling – random, stratified, systematic and multistage. Test of significance – one sample and two sample problems, X^2 test for homogeneity, independence and goodness of fit, test for correlations and regression coefficient.

Practical
Application, layout and analysis of data of principle experimental designs – randomized blocks, latin squares, complete randomized design, split plot, strip plot. Methods of analysis and uses of combined experiments, group of experiments, missing plot techniques. Transformation of data, factorial experiments, concept of mean effect and interaction, concept of confounding. Fitting of curvilinear regressions. Sampling in field experiments and experiments on cultivator's fields. Use of computer in statistical analysis.

4. Horticulture

1st Semester

Major	HOR 501*	Propagation and nursery management in Horticultural crops	2+1
	HOR 502*	Tropical and dry land fruit production	1+1
	HOR 503*	Production technology of cool season vegetable crops	1+1
	HOR 504*	Production technology of cut and loose flowers	1+1
Minor	GPB 503	Principles of Plant Breeding	2+1

Total: 12 credits

2nd Semester

Major	HOR 505	Post harvest technology for horticultural crops	2+1
	HOR 507	Subtropical and temperate fruit production	1+1
	HOR 508	Production technology of warm season vegetable crops	1+1
Minor	SST 504	Seed processing and storage	2+1
Supportive	SPC 599	Basic Statistics and Experimental Design	1+2

Total: 13 credits

3rd Semester

Major	HOR 506	Fundamentals of plantation, spices, medicinal and aromatic crops	1+1
	HOR 509	Landscaping and ornamental gardening	1+1
	HOR 510	Breeding of horticultural crops	2+1
	HOR 511	Technological advancements in fruit, vegetable and ornamental crops	2+0
Minor	PPY 551	Mineral nutrition	2+1

Total: 12 credits

4th Semester

Supportive	HOR 598	Principles of Crop Protection	1 + 1
	HOR 592	Seminar	1
	HOR 593	Dissertation	20

Total: 23 credits

Total credits = 60

Horticulture

Major Courses	Course Title	Credit
HOR 501* Horticultural crops	Propagation and nursery management in	2+1
HOR 502*	Tropical and dry land fruit production	1+1
HOR 503*	Production technology of cool season vegetable crops	1+1
HOR 504*	Production technology of cut and loose flowers	1+1
HOR 505	Post harvest technology for horticultural crops	2+1
HOR 506*	Fundamentals of plantation, spices, medicinal and aromatic crops	1+1
HOR 507	Subtropical and temperate fruit production	1+1
HOR 508	Production technology of warm season vegetable crops	1+1
HOR 509	Landscaping and ornamental gardening	1+1
HOR 510	Breeding of horticultural crops	2+1
HOR 511 and ornamental crops	Technological advancements in fruit, vegetable	2+0

Minor Courses

GPB 503	Principles of Plant Breeding	2+1
SST 504	Seed processing and storage	2+1
PPY 551	Mineral nutrition	2+1

Supporting Courses

SPC 599	Basic Statistics and Experimental Design	1 + 2
SPC 598	Principles of Crop Protection	1 + 1

HOR 501 Propagation and nursery management in Horticultural crops 2+1

Theory

Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixis, polyembryony, chimeras. Principles factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth. Seed quality, treatment, packing, storage, certification, testing. Asexual propagation – rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods. Budding and grafting – selection of elite mother plants, methods.Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank. Orchard establishment and orchard floor management. Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture.Hardening, packing and transport of micro-propagules. Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical

Identification of various horticultural crops, garden plants, garden implements etc; preparation of rooting media; potting and repotting Anatomical studies in rooting of cutting and graft union, various techniques of asexual propagation(cutting, budding, grafting, layering), study and preparation of of media and PGR. Hardening – case studies, micropropagation, explant preparation, media preparation, culturing – *invitro* clonal propagation and visit to TC labs. Preparation of seed bed/nursery bed for vegetables and annuals; economic analysis; visit to commercial nurseries etc.

HOR 502 Tropical and dry land fruit production 1+1

Theory

Commercial varieties of regional, national and international importance,ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bioregulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports.

Crops

Mango and Banana
Citrus and Papaya
Guava, Sapota and Jackfruit
Pineapple, Annonas and Avocado
Aonla, Pomegranate, Phalsa and Ber, minor fruits of tropics

Practical
Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.

HOR 503 Production technology of cool season vegetable crops 1+1

Theory
Classification of vegetable crops, types of vegetable farming, factors affecting vegetable productivity, economics, marketing and export potential of vegetable crops etc.
Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:
Potato
Cole crops: cabbage, cauliflower, knoll kohl, sprouting broccoli, Brussels sprout
Root crops: carrot, radish, turnip and beetroot
Bulb crops: onion and garlic
Peas and broad bean, green leafy cool season vegetables

Practical
Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial vegetable growing areas, farm etc..

HOR 504 Production technology of cut and loose flowers 1+1

Theory
Importance of flower crops and ornamental plants. Global Scenario of flower production and trade, classification of ornamental plants. Scope of cut flowers in global trade, Global scenario of cut flower production, varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices. Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth and flowering. Flower production – water and nutrient management, fertigation, weed management, ratooning, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes. Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation. Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, Storage and transportation, marketing, export potential,institutional support, Agri Export Zones. For Loose Flowers-Harvest indices, harvesting techniques, post-harvest handling and grading, pre-

cooling, packing and storage, value addition, concrete and essential oil extraction, trasportation and marketing, export potential, institutional support, Agri Export Zones.

Crops for Cut flowers: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose,orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria,, bromeliads, dahlia, cut foliages and fillers.

Crops for Loose flowers : Jasmine, scented rose, chrysanthemum, marigold, tuberose,crossandra, nerium, hibiscus, barleria, celosia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies, champaka, pandanus).

Practical

Botanical description of varieties, propagation techniques, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching,disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers and commercial loose flowers, visits to fields, essential oil extraction units and markets.Visit to commercial cut flower units and case study.

HOR 505 Post harvest technology for horticultural crops 2+1

Theory

History and importance of post harvest technology; Composition and nutritive value of horticultural crops .Factors leading to post-harvest loss. Maturity indices, harvesting practices for specific market requirements,,influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration. Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling. Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage : ventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies ,candies. Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of vase life extension in cut flower using chemicals, estimation of quality characteristics in stored fruits and vegetables, cold chain management - visit to cold storage and CA storage units, visit to fruit and vegetable processing units, project preparation, evaluation of processed horticultural products.

HOR 506 Fundamentals of plantation, spices, medicinal and aromatic crops 1+1

Theory

Importance of plantation crops grown in India. Role of plantation crops in national economy and export potential. Plant multiplication, systems of cultivation, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, nutritional and water requirements, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting and processing of produce of: Coffee, Tea,Cashew, Arecanut, Coconut and Betelvine. Introduction; importance of spice crops; historical accent, present status (national and international), future prospects and export potential of spice crops; organic spices. Climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed /planting material, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, harvesting, post harvest management, plant protection measures of: Black pepper, cardamom, turmeric, ginger and garlic. Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, Classification of medicinal crops. Production technology, post harvest handling (drying, processing, grading, packing and storage), processing and value addition and quality standards in herbal products for Senna, Periwinkle, Aswagandha, Sarpagandha, *Dioscorea* sp., *Aloe vera*, medicinal solanum, Isabgol, Poppy and *Ocimum sp.* Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry. Production technology, post-harvest handling, distillation methods, value addition, aroma chemicals,quality standards and regulations for palmarosa, lemongrass, citronella, vettiver, geranium, mentha, ocimum, eucalyptus, patchouli and lavender.

Practical

Plantation crops: Description of botanical and crop varietal features in coconut and arecanut. Project preparation for establishing plantations, Visit to plantations. Spice crops: Identification of spice crops, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, their packaging and processing, value addition; short term experiments on spice crops. Medicinal Plants: Botanical description, Propagation techniques. Project preparation for commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units. Aromatic Plants: Extraction of Essential oils, Project preparation for commercially important Aromatic crops, Visit to distillation and value addition units.

HOR 507 Subtropical and temperate fruit production 1+1

Theory

Commercial varieties of regional, national and international importance,ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation,bioregulation, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, abiotic factors limiting production,physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing,precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones (AEZ) and industrial support.

Crops

Apple, pear, grapes

Plums, peach, apricot, cherries, hazlenut
Litchi, longan, loquat, persimmon, kiwifruit, strawberry
Nuts- walnut, almond, pistachio, pecan
Minor fruits- mangosteen, carambola, bael, wood apple, fig, jamun, rambutan,

Practical
Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analysis of quality attributes, visit to orchards. Project preparation for establishing commercial orchards

HOR 508 Production technology of warm season vegetable crops 1+1

Theory
Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of:
Tomato, eggplant, hot and sweet peppers
Okra, Different types of beans and cowpea
Cucurbitaceous crops
Tapioca and sweet potato
Green leafy warm season vegetables

Practical
Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

HOR 509 Landscaping and ornamental gardening 1+1

Theory
Landscape designs, types of gardens, English, Mughal, Japanese, Persian,Spanish, Italian, Vanams, Buddha garden; Styles of garden, formal,informal and free style gardens. Urban landscaping, Landscaping for specific situations, institutions,industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks,corporates. Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing. Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Brief ideas about pot culture, bonsai, hanging

baskets, avenue trees, herbaceous and shrubbery borders etc. Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves. Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping. Production technology for selected ornamental plants

Practical

Selection of ornamental plants**,** practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens,burlapping, lawn making, planting herbaceous and shrubbery borders,project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden. Creation of garden components with ARCHICAD. Using Photoshop package for 3D picture insertion.

HOR 510 Breeding of horticultural crops 2+1

Theory

Breeding of Fruit crops: Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches for crop improvement -introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Tropical and Subtropical fruit crops: Mango, banana, citrus, grapes, guava, papaya, litchi, ber and pineapple.

Temperate fruits: Apple, pear, plums, peach and strawberry

Breeding of Vegetable Crops: Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives,breeding methods (introduction, selection, hybridization, mutation),varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding of vegetable crops-Issue of patenting, PPVFR act.

Vegetable crops to be dealt with are Potato, tomato, eggplant, hot pepper, sweet pepper, okra, peas and beans, amaranth, cucurbits, cabbage, cauliflower, carrot, beetroot, radish, sweet potato and onion.

Breeding of flower crops: Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants-- introduction, selection, domestication,polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops. Genetic inheritance - of flower colour, doubleness, flower size, fragrance, post harvest life. Breeding constraints and achievements made in commercial flowers - rose,jasmine, chrysanthemum, marigold, tuberose, , carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia and liliums.

Practical

Fruit Crops: Characterization of germplasm, blossom biology, study of anthesis, practices in hybridization, evaluation of biometrical traits and quality traits, screening for resistance, visit to research stations working on tropical, subtropical and temperate fruit improvement.

Vegetable Crops: Analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques. Visit to breeding blocks.
Flower Crops: Description of botanical features– Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, screening of plants for biotic, abiotic stresses and environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

HOR 511 Technological advancements in fruit, vegetable ornamental crops 2+0

Theory

Organic horticulture – definition, principles, methods, merits and demerits. IFOAM and global scenario of organic movement. Organic farming systems. Components of organic horticultural systems. Different organic inputs, their role in organic horticulture. Sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, organic horticulture in quality improvement. Post-harvest management of organic produce. Certification. Organic horticulture and export. Objective, importance and scope of protected cultivation of vegetable, fruits, flowers and ornamental plants. World scenario, Indian situation: present and future. Principles and structures used in protected cultivation including hotbed, cold frame, glasshouse polyhouse, shade net, low tunnels, rain shelters etc. Interaction of light, temperature, humidity, CO_2, water on crop regulation. Greenhouse heating, cooling, ventilation and shading. Containers and substrates, soil decontamination. Water and nutrient management., Automated greenhouses. Management of pest and diseases. Selection of crops and varieties. Recent advancement. Basic concept and application of biotechnology in horticultural crops. Construction and identification of somatic hybrids and cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops.
Recent advancement in various horticultural technologies

SPC 598 Principles of crop protection 1+1

Objective

To familiarize the students about the pests, pesticides and methods of pest control.

Theory

Concept, nomenclature and distribution of pests. History, concept and methods of pest control.
Principles of pest control. Pesticide classification based on use, chemistry and target. Mode and mechanisms of action of pesticide. Fate and persistence of pesticides in environment. Pesticide active ingredient, formulation, adjuvant and sefeners. Pesticide application techniques, equipments and accessories. Pest management in important field and horticultural crops and cropping system. Concept and application of Integrated Pest Management

Practical
Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops. Pesticide calculation, residue estimation and determination of LD_{50} value. Symptoms and management of diseases of different vegetable crops.

SPC 599 Basic Statistics and Experimental Design 1+2

Theory
Meaning and scope of statistics, collection, scrutiny and presentation of data. Frequency distribution and diagrammatic representation. Measures of central tendency – mean, mode, median. Measures of dispersion – range , quartile deviation, mean deviation standard deviation, relative dispersions. Concept and measurement of skewness and kurtosis. Bivariate data and their summarization, scatter diagram, correlation, linear and non-linear regression. Elementary probability theory and normal distribution. Population and sample, parameter and statistics, sampling distribution of statistics and its standard error. Method of sampling – random, stratified, systematic and multistage. Test of significance – one sample and two sample problems, X^2 test for homogeneity, independence and goodness of fit, test for correlations and regression coefficient.

Practical
Application, layout and analysis of data of principle experimental designs – randomized blocks, latin squares, complete randomized design, split plot, strip plot. Methods of analysis and uses of combined experiments, group of experiments, missing plot techniques. Transformation of data, factorial experiments, concept of mean effect and interaction, concept of confounding. Fitting of curvilinear regressions. Sampling in field experiments and experiments on cultivator's fields. Use of computer in statistical analysis.

5. Plant Physiology

1st Semester

Major	PPY 501*	Principles of Plant Physiology	2+1
	PPY 504*	Hormonal regulation of plant growth and development	2+1
	PPY 510	Physiological and molecular aspects of photosynthesis - carbon and nitrogen assimilation	2+1
Minor	AGRO 501	Modern concept of crop production	3+0

Total: 12 credits

2nd Semester

Major	PPY 503*	Physiological and molecular responses of plants to abiotic stress	2+0
	PPY 508	Morphogenesis, tissue culture and transformation	2+1
	PPY 502*	Plant Developmental Biology – Physical and molecular basis	2+0
Minor	ACS 511	Analytical techniques and instrumental methods in soil and plant analysis	1+2
Supportive	SPC 599	Basic Statistics and Experimental Design	1+2

Total: 13 credits

3rd Semester

Major	PPY 511	Mineral Nutrition	2+1
	PPY 506	Physiology of growth and yield and modelling	2+1
	PPY 507	Genome organization in higher plants	3+0
Minor	GPB 601	Plant Genetic Resources Conservation and IPR	2+1

Total: 12 credits

4th Semester

Supportive	SPC 598	Principles of Crop Protection	1+1
Seminar	PPY 591		1
Dissertation	PPY 592		20

Total: 23 credits

Total credits = 60

Plant Physiology

Major Courses	Course Title	Credit
PPY 501*	Principles of Plant Physiology	2+1
PPY 502*	Plant Developmental Biology – Physical and molecular basis	2+0
PPY 503*	Physiological and molecular responses of plants to abiotic stress	2+0
PPY 504*	Hormonal regulation of plant growth and development	2+1
PPY 506	Physiology of growth and yield and modelling	2+1
PPY 507	Genome organization in higher plants	3+0
PPY 508	Morphogenesis, tissue culture and transformation	2+1
PPY 510	Physiological and molecular aspects of photosynthesis - carbon and nitrogen assimilation	2+1
PPY 511	Mineral Nutrition	2+1

Minor Courses

ACS 511 and Plant Analysis	Analytical Techniques and Instrumental Methods in Soil	1+2
AGRO 501	Modern concept of crop production	3+0
GPB 601	Plant Genetic resources	2+1

Supportive Course

SPC 599	Basic Statistics and Experimental Design	1+2
SPC 598	Principles of Crop Protection	1+1

PPY 501 Principles of Plant Physiology 2+1

Objective
To acquaint the students with the basic concepts of water relations and mineral nutrition and their application in agriculture.

Theory
Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions. Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells. Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants – Mycorhizal association on water uptake. Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpiration –Driving force for transpiration, plant factors influencing transpiration rate. Stomata structure and function – mechanism of stomatal movement, antitranspirants. Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance. The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants. Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition. Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants.

Practical
Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe, Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test. Theory and principle of pressure bomb, psychrometer and osmometer, Measurement of transpiration rate. Measurement of vapour pressure deficits, theory and principle of porometry, diffusion prometer and Steady state porometer, Stomatal physiology, influence of ABA on stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiency symptoms of nutrients

PPY 502 Plant Developmental Biology Physiological and Molecular Basis 2+0

Objective
To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

Theory
Plant Biodiversity, Concept of evolution in plants. General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth. Seed Germination and Seedling Growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth. Shoot, Leaf and Root Development – Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages. Floral Induction and Development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination. Seed Development and

Dormancy – Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy. Senescence and Programmed Cell Death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants. Light Control of Plant Development – Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants

Embryonic Pattern Formation – Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants. Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize. Special Aspects of Plant Development and Differentiation – Pollen germination and pollen tube guidance; Phloem differentiation; Sex determination in plants; Self-incompatibility and its genetic control; Heterosis and apomixis.

PPY 503 Physiological and Molecular Responses of Plants to Abiotic Stresses 2+0

Objective

To apprise the students regarding abiotic stress to plant and its molecular basis.

Theory

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses. Drought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept. Transpiration and its regulation – stomatal functions. Physiological processes affected by drought. Drought resistance mechanisms: Escape, Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait. Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products. Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.). High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's. Chilling stress: Effects on physiological processes. Crucial role of membrane lipids. Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

PPY 504 Hormonal Regulation of Plant Growth and Development 2+1

Objective

To apprise the students about the function of plant growth regulator on growth and development of plant.

Theory

Definition and classifiacation of palnt growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. tricontanol, Phenols – polyamines, jasmonates, concept of death hormone. Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberllins, cytokinins, Abscisic acid and Ethylene Brassinosteroids. Hormone mutants and transgenic plants in understanding role of hormones. Signal perception.transduction, and effect at functional gene level of different hormones - Auxins- cell elongation, Gibberellins -, germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plant parts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening. Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development. Synthetic growth regulators- Classification, their effect on plant growth and development.

Practical

Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect on rooting of cuttings, abscission, apical dominance, Gibberellins- bioassays-GA effect on germination of dormant seeds, cytokinin- bioassays- estimation using immunoassay technique cytokinin effect on apical dormance and senescence, ABA bio assays estimation using immunoassay technique. ABA effect on somatal movement, Ethylene bioassays, estimation using physico chemical techniques- Use of hormones in breaking dormancy.

PPY 506 Physiology of Growth, Yield and Modeling 2+1

Objective

To impart knowledge regarding crop growth analysis and different yield prediction models.

Theory

Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity-the concept of rate limitation Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration. Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI. Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index. Plant growth analysis techniques, yield structure analysis, theoretical and actual yields. Plant ideotypes, Simple physiological yield models- Duncan's. Monteith's, and Passioura's Crop growth models-empirical models testing and yield prediction.

Practical

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA partitioning efficiency ,HI, Measurement of light interception, light extinction coefficient, energy utilization efficiency based on energy intercepted, and realized, Computer applications in plant physiology, crop productivity and modeling.

PPY 507 Genome Organization in Higher Plants 3+0

Objective
To impart basic concept on genome organization in prokaryotic and eukaryotic system

Theory
Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, autoptetraploids and polyploids. Gene and gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokayotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept. Mitochondrial and chloroplastic genome organization and regulation of gene expression. Eukaryotic genome structure: Organization and replication; control of gene expressiontranscription and post-transcriptional; promoter analysis; concept of cis elements; transcription factors, function and role of RNA polymerases. Genetic code and translation-deciphering the genetic code; Codon bias; tRNAs, ribosomes; Initiation and termination of translation; Translational and post-translational controls; Attenuation; Suppressor tRNAs. Mobile genetic elements; Structure and function of transposable elements; Mechanism of transposition; Special features of retro transposans; Repair and recombination

PPY 508 Morphogenesis, Tissue Culture and Transformation 2+1

Objective
To impart knowledge about cellular basic of growth and morphogenesis in plants.

Theory
Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation. The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency. Introduction to in vitro methods : Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country (ovary and ovule culture , in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids. Introduction to the processes of embryogenesis and organogenesis and their practical applications : Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot – tip and meristem culture. Haploids and their applications. Somaclonal variations and applications (treasure your exceptions). Introduction to protoplast isolation : Principles and applications . Testing of viability of isolated protoplast . Various steps in the regeneration of protoplast . Somatic hybridization – an introduction, Various methods for fusing protoplast, chemical and electrical . Use of makers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids) Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introdiuction to *A. tumefaciens*. Tumour formation on plants using *A. tumefaciens* (Monocots vs Dicots), Root – formation using *A.rhizogenes*

Practical
In vitro culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethlyne on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

PPY 510 Physiological and Molecular Aspects of Photosynthesis - Carbon and Nitrogen Assimilation 2+1

Objective
To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory
Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere. Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield. Photosynthetic carbon reduction cycle and its regulation. CO2 Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C4, CAM and single celled C4 organisms, C3-C4 intermediates. Ecological significance of CCM. Rubisco structure, assembly and kinetics, photorespiration and its significance. Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of ra, rs and rm. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc. Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity – transgenics. Conceptual approaches of expressing C4 photosynthesis genes in C3 species. Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and no-photochemical quenching of chlorophyll fluorescence. Photosynthesis and
transpiration interaction, significance of WUE, carbon isotope discrimination concept. Prospects of improving photo synthetic rate and productivity – potential traits of photosynthesis biotechnological approaches. Nitrogen assimilation in photosynthesizing cells – NO3,-, NO2- reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its reassimilation and NUE.

Practical
Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O_2 evolution, Determination of rubisco content (western and ELISA), activity and activation state, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates – WUE by gas exchange rates. Light, CO2, VPD response curves, Determination of photorespiration by gas exchange- (TPSAPS).Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception, Determination of NH4+, reduction of inorganic nitrogen species.

PPY 511 Mineral Nutrition 2+1

Objective
To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory
Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system. Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity. Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation. Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels. Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties. Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practical
Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities.

SPC 598 Principles of crop protection 1+1

Objective
To familiarize the students about the pests, pesticides and methods of pest control.

Theory
Concept, nomenclature and distribution of pests. History, concept and methods of pest control.
Principles of pest control. Pesticide classification based on use, chemistry and target. Mode and mechanisms of action of pesticide. Fate and persistence of pesticides in environment. Pesticide active ingredient, formulation, adjuvant and sefeners. Pesticide application techniques, equipments and accessories. Pest management in important field and horticultural crops and cropping system. Concept and application of Integrated Pest Management

Practical
Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops. Pesticide calculation, residue estimation and determination of LD_{50} value. Symptoms and management of diseases of different vegetable crops.

SPC 599 Basic Statistics and Experimental Design 1+2

Theory
Meaning and scope of statistics, collection, scrutiny and presentation of data. Frequency distribution and diagrammatic representation. Measures of central tendency – mean, mode, median. Measures of dispersion – range , quartile deviation, mean deviation standard deviation, relative dispersions. Concept and measurement of skewness and kurtosis. Bivariate data and their summarization, scatter diagram, correlation, linear and non-linear regression. Elementary probability theory and normal distribution. Population and sample, parameter and statistics, sampling distribution of statistics and its standard error. Method of sampling – random, stratified, systematic and multistage. Test of significance – one sample

and two sample problems, X^2 test for homogeneity, independence and goodness of fit, test for correlations and regression coefficient.

Practical

Application, layout and analysis of data of principle experimental designs – randomized blocks, latin squares, complete randomized design, split plot, strip plot. Methods of analysis and uses of combined experiments, group of experiments, missing plot techniques. Transformation of data, factorial experiments, concept of mean effect and interaction, concept of confounding. Fitting of curvilinear regressions. Sampling in field experiments and experiments on cultivator's fields. Use of computer in statistical analysis.

6. SEED SCIENCE AND TECHNOLOGY (SST)

1st semester

CODE	COURSE TITLE	CREDIT
SST 501*	Principles of seed production	3 + 0
SST 502	Seed physiology	2 + 1
SST 503*	Seed production in field crops	2 + 1
AGRO 501	Modern concept of crop production	3 + 0
		12 credit

2nd semester

CODE	COURSE TITLE	CREDIT
SST 504*	Seed processing and storage	2 + 1
SST 505*	Floral Biology, seed development and maturation	2 + 1
SST 506	Developmental and germination physiology	1 + 1
SST 507	Seed pathology and Entomology	1 + 1
SPC 599	Basic statistics, design and computer application	1 + 2
		13 credit

3rd semester

CODE	COURSE TITLE	CREDIT
SST 508*	Seed legislation and certification	2 + 1
SST 509	Seed production in vegetables, fruits and plantation crops	2 + 0
SST 510	Seed production in flowers, spices and medicinal plants	1 + 0
HOR 501	Plant propagation and Nursery management	2 + 1
GPB 503	Principles of plant breeding	2 + 1
		12 credit

4th semester

CODE	COURSE TITLE	CREDIT
SPC 598	Principles of crop protection	1 + 1
SST 591	Seminar	1
SST 592	Dissertation	20
		23 credit

TOTAL : 60 credit

SEED SCIENCE AND TECHNOLOGY (SST)

Major Courses	Course Title	Credit
SST 501*	Principles of seed production	3+0
SST 502	Seed physiology	2+1
SST 503*	Seed production in field crops	2+1
SST 504*	Seed processing and storage	2+1
SST 505*	Floral Biology, seed development and maturation	1+1
SST 506	Developmental and germination physiology	1+1
SST 507	Seed pathology and Entomology	1+1
SST 508*	Seed legislation and certification	2+1
SST 509	Seed production in vegetables, fruits and plantation crops	2+0
SST 510	Seed production in flowers, spices and medicinal plants	2+0
SST 511	Seed production in forage and pasture crops	2+0
SST 512	Seed health Management	2+1
SST 513	Plant Quarantine	2+0
SST 514	Seed Farm Management and Marketing	2+0
Minor Course		
GPB 503	Principles of plant breeding	2+1
AGRO 501	Modern concept of crop production	3+0
HOR 501	Plant propagation and Nursery management	2+1
Supporting Course		
SPC 599	Basic statistics, design and computer application	1+2
SPC 598	Principles of crop protection	1+1

SST 501 Principles of seed production (3 + 0)

Seed as a basic input in agriculture, difference between seed and grain, concept of quality seed, quality control in seed production, role of high quality seed in crop production. Classification of crop plants in relation to mode of reproduction and choice of methods of seed production. Pollination mechanism in plant breeding and crop production. Ecology and dynamic of pollination, specificity of flowers and pollen, pollen dispersal, natural cross pollination rate, artificial control of out-crossing. Concept of genetic purity of varieties, methods of maintenance of genetic purity, isolation distance, general concept of nucleus, breeder, foundation and certified seeds. Concept of hybrid seed production – hand emasculation, and pollinations, detasselling, male sterility, gametocides and self incompatibility. Factor affecting seed set – temperature, humidity, day length, wind velocity, duration of flowering, anthesis, pollen viability, stigma receptivity, nutrition and irrigation. Agronomic management of seed production – selection of suitable agroclimatic region, seed plot, isolation of seed crops, preparation of land, soil types, selection of variety, seed treatment, time of planting, seed rate, method of sowing, depth of sowing, rouging, supplementary pollination, weed control, disease and insect control, nutrition, irrigation, time of harvest, seed drying and storage. Production methods of propagules other than true seeds – cutting, layering, grafting, budding, productions of specialized vegetative structures like tubers, bulbs, rhizomes, suckers, runners, offsets, etc. Seed orchards or plantations. Seed production of forest trees. Seed production system and management – systems of seed production in India, agencies, planning, organizing and managing seed production programme in India and abroad. Systems of release and notification of varieties for general cultivation.

SST 502 Seed physiology (2 + 1)

Plant Cells – its structure and functions, cell wall, cell membranes, permeability and cell organelles. Photosynthesis, respiration and translocation. Photoperiodism – role of light and dark periods in flowering, phytochrome and its role in photoperiodism, thermoperiodicity, vernalization effect of low and high temperature. Synthesis of food reserves – polysaccharides, proteins and lipids. Physiology of seed development, seed maturation and ripening. Dormancy – concept, ecological implications, factors controlling the seed dormancy, cause of seed dormancy and its breakage. Imbibition – pattern of water absorption, kinetics of water uptake, soaking injury, solute leakage, radicle expansion and cell division. Germination – types, factor affecting germination and their implication. Respiratory pathways during germination, breakdown of seed storage products during germination, role of enzyme, auxin, gibberellins, kinins and abscisic acid in relation to germination. Seedling establishment – role of endosperm and embryo size, seedling abnormalities in major dicot and monocot crop species. Micropropagation technique – significance, use, scope and limitation.

Practical :

Pattern of water absorption by starchy, proteinaceous and fatty seeds. Determination of the effect of seed coat on imbibition of water. Determination of temperature coefficient of imbibition of different types of seeds. Estimation of enzymes viz. amylase, dehydrogenase and catalase from seed. Chemical assay of volatile aldehyde production during germination. Determination of starch, reducing and non-reducing sugar.

SST 503 Seed production in field crops (2 + 1)

Seed production technology and certifications of the following crops with special emphasis on soil and climatic requirements, isolation, cultural practices, plant protection, weeding, rouging, field inspection, harvesting, threshing pre-processing care, sealing, bagging and issue of certificates. Cereals – Paddy, Wheat, Jowar, Bajra, Maize, Sorghum and their hybrids. Pulses – Gram, Lentil, Cowpea, Red gram, Greengram, Soybean, Blackgram. Oilseeds – Rape and Mustard, Groundnut, Sunflower, Sesame. Fibres – Jute, Cotton. Sugar Crops – Sugarbeet, Sugarcane, Potato and TPS.

Practical :
Planning of Seed Production. Requirements for different classes of seeds in field crops – unit area and rate. Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines, Synchronization of parental lines and methods to achieve synchrony. Supplementary pollination, pollen storage, hand emasculation and pollination in Cotton, detasselling in Corn, identification of rogues and pollen shedders. Pollen collection, storage, viability and stigma receptivity. Gametocide application and visits to seed production plots etc.

SST 504 Seed processing and storage (2 + 1)

Introduction and importance of seed processing. Different methods of seed drying, including dehumidification and its impact on seed quality. Relative humidity and equilibrium moisture content of seed. Preparing seed for processing : scalper debearder, scarifier, huller, seed cleaner and grader, screen cleaners, specific gravity separators, indented cylinder, separator, velvet separator, spiral separator, disc separator, colour sorter. Seed treatments – methods of seed treatment, seed treating compounds, seed disinfestations. Packaging : Principles and practices and material. Processing plant design and layout. Delinting machines. Seed storage : Importance and factors affecting changes during storage, concepts and significance of moisture equilibrium, method of maintaining safe moisture content. Seed viability – Definition, relationship with seed vigour, factors affecting seed viability. Seed vigour concept and its measurement relationship with crop productivity. Physiological, biochemical and cytological changes associated with the loss of vigour and viability during storage and its control. Thumb rule and its relevance, loss of viability in important agricultural and horticultural crops, viability equation and monograph. Conservation of orthodox and recalcitrant seeds. Methods to minimize the loss of seed vigour and viability. Mechanism of seed deterioration in storage, symptoms of seed deterioration, causes and its implications on seed quality. Seed borne fungi and seed borne plant disease, agents during storage; seed pests, loss due to pests and their control. Invigoration treatments – effect on storability, vigour, viability and ageing reflection on germination, growth and crop productivity. Storage losses due to pests. Factors influencing storage losses. Storage methods and godown sanitation. Storage structure. Storage pests and their control.

Practical :
Operation and handling of mechanical drying equipments. Effect of drying temperature and duration on seed germination and storability with particular reference to oil seeds. Seed processing equipment. Seed treating equipments. Seed blending. Effect of containers on the storability of seeds. Techniques of moisture determination. Tetrazolium test for seed viability and vigour. Studies on the membrane permeability (leaching of electrolytes, sugar and amino acid) of different vigour seed lots. Determination of lipid peroxidation activity of different vigour seed lots. Different techniques of dry and wet seed

invigoration treatments for viability maintenance. Techniques of artificial and natural ageing. Methods of storage of seeds in coastal and north eastern zones of India

SST 505 Floral biology, seed development and maturation (2 + 1)

Floral biology of cultivated plants. Pollination, fertilization, seed and fruit development. Classification of fruits. Seed structure and texture, seed coat classifications and functions. Endosperm and embryo development, immature seed and germination. Polyembryony and apomixis. Seed constituent, chemical composition of seed, storage tissue, food reserve-storage protein, carbohydrates, starch, polysaccharides, oil and fats, phytins. Hormones and seed developments – Role of gibberellins, auxin, cytokinin and abscisic acid. Testing for cultivar – Genuineness : objectives, general principles and methods, electrophoresis, phenol colour reaction, peroxidise test, GA3 test, isozymes, RFLP (Restriction Fragment Length Polymorphism)/ RAPD (Random Amplified Polymorphic DNA), storage protein banding pattern in crop cultivar identification.

Practical :
Study of floral biology of monocot and dicots. Seed-coat : its structure**,** texture in relation to permeability, imbibitions of water. Heterostyly. Micro and megasporogenesis. Pollen morphology, pollen germination and pollen sterility. Monocot and dicot embryos. External and internal structure of monocot and dicot seeds. Maturity indices.

SST 506 Developmental and Germination Physiology (1 + 1)

Physiology of fertilization and fruit set, physiology of fruit growth – role of seeds, parthenocarpy. Physiological and biochemical changes during fruit ripening, role of ethylene in fruit ripening. Effect of environment before harvesting on viability – changes in weight, moisture and respiration during seed development and maturation – structural changes during ripening, environmental effect on seed structure and composition (mineral nutrition, rainfall and soil moisture, temperature), effect of environment before harvest and the stages of maturity at harvest on seed performance – seed maturity, size, mineral nutrition, temperature and photoperiod. Post-harvest physiology of the fruit, climacteric rise. Physiology of tuber and bud formation, seed and bud dormancy. Dormancy – Function, basis of seed and bud dormancy, innate dormancy, induce and secondary dormancy, hard seededness. Historical aspect and nomenclature of growth substances, physiological roles, biosynthesis and mode of action of auxin, gibberellins, cytokinins, ethylene and abscisic acid. Growth inhibitors and retarding chemicals – Phosphon-D, Morphactin, Malic hydrazide, Cycocel. Use of growth regulators in dormancy and germination of seed, flowering, fruit set and fruit growth, fruit thinning, ripening and post-harvest storage of fruits, bulbs and tubers. Protein synthesis – mechanism, role in seed development and germination. Stress and seed germination – mechanical causes of stress, temperature, light and hormonal alleviation of stress. Seed priming, physiological and biochemical basis of priming.

Practical :
Effect of seed germination under different environmental conditions. Effect of different growth hormones on germination process of different types of seeds. Qualitative and quantitative estimation of organic

acids. Effect of different salt concentrations on germination and seedling growth. Extraction and assay of auxins and gibberellins. Cell, organ and embryo culture techniques.

SST 507 Seed pathology and entomology (1 + 1)

Importance of seed pathology in seed industry. Seed diseases caused by externally and internally borne microorganisms and nematodes. Taxonomic aspects of microorganisms occurring in seeds, identification and estimation in seed samples. Transmission of seed borne micro-organisms and their control. Histopathological and biochemical changes occurring in diseased seeds. Mycotoxin and health hazards. Epidemiology of the infection and diseased manifestation condition in seeds. Inoculum density of the pathogens in the development of diseases. Effect of microbial infection on seed quality. Importance of seed losses caused by insects and pests in seed industry. General account of insects associated with cereals, pulses, oil seeds and vegetables. Different aspects of seed treatments, packaging and storage of seeds, methods of storage of seeds in coastal and north-eastern zones in India. Preservation of seed on long term basis. Losses in germination of seeds damaged by insects. Rodents and their control in field and seed godowns. Control measure types, principles, handling of equipment, maintenance and uses. Seed health testing and certification.

Practical :

Isolation and identification of carpophytic microflora and insects. Histopathological demonstration of internally borne pathogens. Estimation and isolation of mycotoxins. Control of seed borne diseases caused by microorganism by chemical treatments. Control of seed borne pests by pesticides. Preservation and maintenance of microorganisms in culture. Role of microorganisms in seed quality deterioration and germination. Survey of insects associated with storage seeds. Preparation of culture media. Methods of isolation and inoculation. Study of microorganisms in pure culture. Morphological study of some important insects associated with storage seeds.

SST 508 Seed legislation and certification (2 + 1)

Regulatory mechanisms of seed quality control – organizations involved in seed quality control programmes. Seed legislation and seed law enforcement as a mechanism of seed quality control. Seed Act (1966), Seed Rules (1968), Seed (Control) Order 1983. Essential Commodities Act (1955). Plants, Fruits and Seeds Order (1989). National Seed Development Policy (1988) and EXIM Policy regarding seeds, plant materials. New Seed Bill-2004 etc. Introduction, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India. Concept and objectives of seed certification. Seed certification agency/ organization and staff requirement. Legal status and phases of seed certification. Formulation, revision and publication of seed certification standards. Indian Minimum Seed Certification Standards (I.M.S.C.S.) – general and specific crop standards including GM varieties, field and seed standards. Planning and management of seed certification programmes – eligibility of a variety for certification, area assessment, cropping history of the seed field, multiplication system based on limited generation concept, isolation and land requirements etc. Seed testing – Introduction, National and International Organization seed testing linkages, testing equipment and their maintenance. Seed sampling – mixing, dividing, heterogeneity test, handling and testing of the samples. Purity analysis – Principles and procedures, germination test, tolerance test, moisture testing. Seedling evaluations – Test for seed quality, seed vigour testing, cultivar purity testing, testing of pelleted seeds, record keeping and

reporting of results. Seed health tests, issue of certificates, seed testing in relation to Seed Act and marketing. Conducting seed surveys.

Introduction seed quality and its concept, physical and genetic purity, concept of variety variation – heritable and non-heritable contaminants to seed purity during seed multiplication. Classes of quality seeds – breeder seed, foundation seed, registered seed and certified seed, requirements for certified and foundation seeds. Development of seed industry in India. Operation essential for a seed industry. Seed quality control systems – seed legislation, seed certification.

Practical :

Seed sampling and physical purity analysis. Study of germination behaviour under different germination media. Testing of seed health by blotter technique. Seed germination tests of health and infected seeds. Raising and management of nursery for different vegetables and flowers. Identification of cereals, vegetables, pulses, oils and flower seeds. Method of identifying varieties of different kinds of seeds by growth out tests, analysis of pelleted or taped seeds. Study of design and construction of seed testing laboratory. Studying the seed certification agency and observation on their operation. Visit to Seed Testing Laboratory/ Seed Farms/ Seed Processing Centre. Preparation of herbarium specimen and field tour.

SST 509 Seed production in vegetables, fruits and plantation crops (2 + 0)

Seed production technology and certifications of the following crops with special emphasis on soil and climatic requirements, isolation, cultural practices, plant protection, weeding, rouging, field inspection, harvesting, threshing, pre-processing care, sealing, bagging and issue of certificates.

Vegetables – Tomato, Brinjal, Chilli, Cabbage, Cauliflower, Okra, Cucurbits, Carrot, Radish, Onion, Potato, Pea and Beans, Lettuce and Spinach. Fruits and plantation crops – Papaya, Citrus, Grapes, Guava, Mango, Jackfruit, Apple, Coconut, Banana, Litchi, Cashew nut, Walnut and Almond. Application of biotechnology in production of seeds and other plants materials, tea and coffee.

SST 510 Seed production in flowers, spices and medicinal plants (1 + 0)

Seed production technology and certifications of the following crops with special emphasis on soil and climatic requirements, isolation, cultural practices, plant protection, weeding, rouging, field inspection, harvesting, threshing, pre-processing, care, sealing, bagging and issue of certificates. Flowers – Lotus, Rose, Gladiolus, Marigold, Chrysanthemum, Carnation, Dahlia, Aster, Zinnia, Lilium, Sweet sultan, Corn flower, Antirrhinum, Gerbera, Anthurium Jesmina and Tuberose. Spices – Coriander, Fennel, Ajowan, Blackcumin, Ginger, Garlic. Medicinal Plants – *Cassia*, Catharanthus, Gymnema, Rosella, *Rauwolfia, Solanum, Ocimum, Aloe vera, Adhatoda vasica, Andrographis paniculata*, Neem and Plantago.

SST 511 Seed production in forage and pasture crops (2 + 0)

Seed production technology and certifications of the following crops with special emphasis on soil and climatic requirements, isolation, cultural practices, plant protection, weeding, rouging, field inspection, harvesting, threshing, pre-processing care, sealing, bagging and issue of certificates. Forages – Barseem, Lucern, Oats, Ragi, Bajra and Gour etc. Pasture crops – Different types of grasses.

SST 512 Seed health management (2 + 1)

Historical development of seed health testing and significance of seed borne diseases and insect pests. Important storage pests, namely seed borne plant pathogens (fungi, bacteria, viruses, viroids, nematodes), insects, mites, rodents and birds associated with seed under field and storage conditions. Detection of seed borne pathogens and insects. Deterioration of damage and estimation of losses, conditions favouring various storage pests. Pest development and control. Management of insect pests, mites, rodents and birds through seed treatments (biological, chemical, physical and mechanical). Seed certification and plant quarantine.

Practices for safe storage, examination of seeds for infection. Washing test, incubation method. Seedling symptomatology test. Histopathology. Embryo Count method. NaOH seed soak method. Immunoassays and nucleic acid based techniques. Collection and identification of storage insect pests. Dose estimation of various seed protectants, methods of fumigation, fumigants, safe handling and use, plant protection equipments and their use.

Practical :

Examination of seeds for infections. Washing test. Incubation methods. Seedling symptomatology test. Histopathology embryo count method. NaOH seed – soak method. Immunoassays and nucleic acid based techniques. Collection and identification of storage pests. Dose estimation of various seed protectants. Methods of fumigation, fumigants, safe handling and use. Plant protection equipments and their use.

SST 513 Plant Quarantine (2 +0)

History and significance of plant quarantine. Principles, scope and prospects of plant quarantine, plant quarantine operations in India. New seed policy in India with reference to plant quarantine. Role of plant quarantine in preventing and checking the spread of insects, plant pathogens, viruses and weeds, nematodes and alien genes. Multilateral agreement for the movement of transgenics. Domestic and international quarantine, its weaknesses and measures for its strengthening. Plant protection convention and international cooperation in plant quarantine. Pest risk analysis. Problems in assessing the overall effectiveness of plant quarantine. Techniques for the detection of insects, mites, nematodes, fungal bacterial pathogens and viruses. Salvaging the germplasm. New exim policy. Plant quarantine authority.

SST 514 Seed Farm Management and Marketing (2 + 0)

Principles of farm management – Tillage, irrigation, plant protection, harvesting and threshing, maintenance of soil fertility, weeds and their control, mixed cropping, multiple cropping and dry land farming.

Farm business analysis – economic size of the farm, farm budgeting, cost and capital investment, profitable combination of inputs and outputs, factors affecting profit, cost analysis, low and diminishing return efficiency measure.

Marketing – Basic concepts, supply and demand, price equilibrium, organization for seed marketing, transportation, storage cost and return, cost of processing and packaging, seed market surveys.

SPC 598 Principles of crop protection 1+1

Objective

To familiarize the students about the pests, pesticides and methods of pest control.

Theory

Concept, nomenclature and distribution of pests. History, concept and methods of pest control.

Principles of pest control. Pesticide classification based on use, chemistry and target. Mode and mechanisms of action of pesticide. Fate and persistence of pesticides in environment. Pesticide active ingredient, formulation, adjuvant and sefeners. Pesticide application techniques, equipments and accessories. Pest management in important field and horticultural crops and cropping system. Concept and application of Integrated Pest Management

Practical

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops. Pesticide calculation, residue estimation and determination of LD_{50} value. Symptoms and management of diseases of different vegetable crops.

SPC 599 Basic Statistics and Experimental Design 1+2

Theory

Meaning and scope of statistics, collection, scrutiny and presentation of data. Frequency distribution and diagrammatic representation. Measures of central tendency – mean, mode, median. Measures of dispersion – range , quartile deviation, mean deviation standard deviation, relative dispersions. Concept and measurement of skewness and kurtosis. Bivariate data and their summarization, scatter diagram, correlation, linear and non-linear regression. Elementary probability theory and normal distribution. Population and sample, parameter and statistics, sampling distribution of statistics and its standard error. Method of sampling – random, stratified, systematic and multistage. Test of significance – one sample and two sample problems, X^2 test for homogeneity, independence and goodness of fit, test for correlations and regression coefficient.

Practical

Application, layout and analysis of data of principle experimental designs – randomized blocks, latin squares, complete randomized design, split plot, strip plot. Methods of analysis and uses of combined experiments, group of experiments, missing plot techniques. Transformation of data, factorial experiments, concept of mean effect and interaction, concept of confounding. Fitting of curvilinear regressions. Sampling in field experiments and experiments on cultivator's fields. Use of computer in statistical analysis.